CLAIMS

(57) [Claim(s)]
[Claim 1] An optical frequency modulation means to input an electrical signal and to output the signal light which carried out the optical frequency modulation, An optical frequency oscillation means to output said signal light and the local oscillation light of optical frequency which left only the predetermined intermediate frequency, It has an optical multiplexing means to multiplex said signal light and said local oscillation light, and a photo-electric-translation means to change and output the output of said optical multiplexing means to an electrical signal. The optical-heterodyne-detection section which outputs the modulating signal which inputted said signal light and carried out frequency conversion to said intermediate frequency, It has an unnecessary on-the-strength component clearance means to remove AM component in the signal which generates an optical frequency modulation means generated in said optical frequency modulation means. Said unnecessary on-the-strength component clearance means The modulation-technique conversion circuit characterized by consisting of a distribution means to distribute the electrical signal inputted into said optical frequency modulation means, and a multiplexing means to multiplex one of the outputs of said distribution means due to the output modulating signal of said optical-heterodyne-detection section, and an opposite phase. [Claim 2] An optical frequency modulation means to input an electrical signal and to output the signal light which carried out the optical frequency modulation, An optical frequency oscillation means to output said signal light and the local oscillation light of optical frequency which left only the predetermined intermediate frequency, It has an optical multiplexing means to multiplex said signal light and said local oscillation light, and a photo-electric-translation means to change and output the output of said optical multiplexing means to an electrical signal. The optical-heterodyne-detection section which outputs the modulating signal which inputted said signal light and carried out frequency conversion to said intermediate frequency, It has an unnecessary on-the-strength component clearance means to remove AM component in the signal which generates an optical frequency modulation means generated in said optical frequency modulation means. Said unnecessary on-the-strength component clearance means The modulation-technique conversion circuit characterized by consisting of a distribution means to distribute the electrical signal inputted into said optical frequency modulation means, and an optical intensity modulation means which carries out intensity modulation of the output signal light of said optical frequency modulation means with one output of said distribution means. [Claim 3] An optical frequency modulation means to input an electrical signal and to output the signal light which carried out the optical frequency modulation, An optical frequency oscillation means to output said signal light and the local oscillation light of optical frequency which left only the predetermined intermediate frequency, It has an optical multiplexing means to multiplex said signal light and said local oscillation light, and a photo-electric-translation means to change and output the output of said optical multiplexing means to an electrical signal. The optical-heterodyne-detection section which outputs the modulating signal which inputted said signal light and carried out frequency conversion to said intermediate frequency, It has an unnecessary on-the-strength component clearance means to remove AM component in the signal which generates an optical frequency modulation means generated in said optical frequency modulation means. Said unnecessary on-the-strength component clearance means Optical intensity modulation of one side of the output of a dichotomy means to dichotomize the output signal light of said optical frequency modulation means, and said dichotomy means is carried out. An optical intensity modulation means to supply the output which carried out optical intensity modulation to said optical-heterodyne-detection section, The modulation-technique conversion circuit which changes another output of said dichotomy means into an electrical signal, and is characterized by consisting of an optical/electrical converter for inputting the changed electrical signal into said optical intensity modulation means as a modulating signal by the opposite phase. [Claim 4] An optical

frequency modulation means to input an electrical signal and to output the signal light which carried out the optical frequency modulation, An optical frequency oscillation means to output said signal light and the local oscillation light of optical frequency which left only the predetermined intermediate frequency, It has an optical multiplexing means to compound said signal light and said local oscillation light, and the 1st photo-electric-translation means which changes and outputs the output of said optical multiplexing means to an electrical signal. The modulation-technique conversion circuit which consists of the optical-heterodyne-detection section which outputs the modulating signal which inputted said signal light and carried out frequency conversion to said intermediate frequency, The optical sending set which consists of a transmitting means to output the transmitting light which carried out intensity modulation with the output of said modulation-technique conversion circuit, In the lightwave signal transmission equipment which is connected to an optical transmission line and said optical sending set through said optical transmission line, and is equipped with the optical receiving set which consists of the 2nd photo-electric-translation means and a frequency recovery means which carries out the frequency recovery of the output of said 2nd photo-electric-translation means It has an unnecessary on-the-strength component clearance means to remove AM component in the signal which generates an optical frequency modulation means generated in said optical frequency modulation means. Said unnecessary on-the-strength component clearance means Lightwave signal transmission equipment characterized by consisting of a distribution means to distribute the electrical signal inputted into said optical frequency modulation means, and a multiplexing means to multiplex one of the outputs of said distribution means due to the output modulating signal of said optical-heterodyne-detection section, and an opposite phase. [Claim 5] An optical frequency modulation means to input an electrical signal and to output the signal light which carried out the optical frequency modulation, An optical frequency oscillation means to output said signal light and the local oscillation light of optical frequency which left only the predetermined intermediate frequency, It has an optical multiplexing means to compound said signal light and said local oscillation light, and the 1st photo-electric-translation means which changes and outputs the output of said optical multiplexing means to an electrical signal. The modulation-technique conversion circuit which consists of the optical-heterodyne-detection section which outputs the modulating signal which inputted said signal light and carried out frequency conversion to said intermediate frequency, The optical sending set which consists of a transmitting means to output the transmitting light which carried out intensity modulation with the output of said modulation-technique conversion circuit, In the lightwave signal transmission equipment which is connected to an optical transmission line and said optical sending set through said optical transmission line, and is equipped with the optical receiving set which consists of the 2nd photo-electric-translation means and a frequency recovery means which carries out the frequency recovery of the output of said 2nd photo-electric-translation means It has an unnecessary on-the-strength component clearance means to remove AM component in the signal which generates an optical frequency modulation means generated in said optical frequency modulation means. Said unnecessary on-the-strength component clearance means Lightwave signal transmission equipment characterized by consisting of a distribution means to distribute the electrical signal inputted into said optical frequency modulation means, and an optical intensity modulation means which carries out intensity modulation of the output signal light of said optical frequency modulation means with one output of said distribution means.

[Claim 6] An optical frequency modulation means to input an electrical signal and to output the signal light which carried out the optical frequency modulation, An optical frequency oscillation means to output said signal light and the local oscillation light of optical frequency which left only the predetermined intermediate frequency, It has an optical multiplexing means to compound said signal light and said local oscillation light, and the 1st photo-electric-translation means which changes and outputs the output of said optical multiplexing means to an electrical signal. The modulation-technique conversion circuit which consists of the optical-heterodyne-detection section which outputs the modulating signal which inputted said signal light and carried out frequency conversion to said intermediate frequency, The optical sending set which consists of a transmitting means to output the transmitting light which carried out intensity modulation with the output of said modulation-technique conversion circuit, In the lightwave signal transmission equipment which is connected to an optical transmission line and said optical sending set through said optical transmission line, and is equipped with the optical receiving set which consists of the 2nd photo-electric-translation means and a frequency recovery means which carries out the frequency recovery of the output of said 2nd photo-electric-translation means It has an unnecessary on-the-strength component clearance means to remove AM component in the signal which generates an optical frequency modulation means generated in said optical frequency modulation means. Said unnecessary on-the-strength component clearance means Optical intensity modulation of one side of the output of a dichotomy

means to dichotomize the output signal light of said optical frequency modulation means, and said dichotomy means is carried out. An optical intensity modulation means to supply the output which carried out optical intensity modulation to said optical-heterodyne-detection section, Lightwave signal transmission equipment which changes another output of said dichotomy means into an electrical signal, and is characterized by consisting of an optical/electrical converter for inputting the changed electrical signal into said optical intensity modulation means as a modulating signal by the opposite phase.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the modulation-technique conversion circuit and lightwave signal transmission equipment which are used for the optical transmission of a broadband signal. This invention relates to the modulation-technique conversion circuit and lightwave signal transmission equipment which were suitable for carrying out optical transmission of the multi-channel video signal by which frequency division multiplex is carried out, and by which amplitude modulation was carried out, and were suitable for using by the passive double star (PDS) light subscriber system especially in more detail.
[0002]
[Description of the Prior Art] In current and each country, researches and developments of the optical transmission method which changes and transmits a broadband electrical signal to a lightwave signal as an approach of transmitting a multi-channel video signal are furthered energetically. There is a method (henceforth an AM-TV transmission system) which carries out intensity modulation of the semiconductor laser to one of them in proportion to the amplitude of the multi-channel video signal by which amplitude modulation is carried out, and carries out optical transmission of the lightwave signal which carried out intensity modulation to it. The AM-TV transmission system is mainly used for the trunk system optical transmission of cable television. However, since an AM-TV transmission system has small noise proof stress, it has the technical problem that the large level difference between transmission and reception cannot be taken, and the large transmission distance and the optical large degree in an optical transmission system cannot be taken.
[0003] In order to solve this technical problem, after carrying out the frequency modulation of the multi-channel video signal beforehand for every channel, the method (henceforth the FM-TV transmission system according to image channel individual) which carries out intensity modulation of the semiconductor laser, and carries out optical transmission was developed. Since the FM-TV transmission system according to image channel individual has large noise proof stress, it can take a transmission distance and an optical large degree in the big optical transmission system of the level difference between transmission and reception. However, by this method, since it must get over after choosing a channel, and a channel selection circuitry will become complicated in a broadband, the technical problem that a receiver will become expensive occurred.
[0004] On the other hand, after the multi-channel video signal was put in block with many channels and carried out frequency modulation as a different thing from these, intensity modulation of the semiconductor laser was carried out, optical transmission of the modulating-signal light was carried out, and research and development in the method (henceforth a package FM-TV transmission system) to which bundles up by the receiving side and it restores to a multi-channel video signal was done. Since a package FM-TV transmission system has large noise proof stress, it can take a transmission distance and an optical large degree in an optical transmission system with the large level difference between transmission and reception. And although the signal by which optical transmission is carried out is a broadband, since channel selection can be carried out with the general-purpose tuner for cable television from the signal to which could restore in the easy circuit and it restored by using a high speed IC, a receiver can be constituted cheaply.
[0005]
[Problem(s) to be Solved by the Invention] However, since the modulator which carries out the frequency modulation of the multi-channel video signal collectively is conventionally constituted using the voltage controlled oscillator (it is hereafter described as VCO), a limit is in the frequency band which can be modulated by the band limit of the input frequency of VCO. Since the input impedance of VCO generally becomes large in a

RF, about 200MHz of the electrical signal which can be inputted into VCO is a limitation. Since it is restricted by the frequency (for example, 90MHz) of a radio broadcasting, the minimum of a frequency band usable to transmission of television broadcasting serves as a frequency band which can be used for transmission of an about 90-200MHz band of television broadcasting, when using VCO. For example, if transmission band width of face required for transmission per channel of television broadcasting is set to 6MHz, in using VCO, the number of the image channels which can be transmitted simultaneously will become about 20 channels. Furthermore, producing VCO which crosses to a large frequency band and maintains linearity also has a problem on production of being difficult.
[0006] This invention was made under such a background, can carry out [broadband]-izing of the frequency band compared with the former, and aims at offering the lightwave signal transmission equipment using the modulation-technique conversion circuit and it which make possible a quality signal transmission with few distortion and noises.
[0007]
[Means for Solving the Problem] In order to solve the above-mentioned technical problem, invention according to claim 1 An optical frequency modulation means to input an electrical signal and to output the signal light which carried out the optical frequency modulation, An optical frequency oscillation means to output said signal light and the local oscillation light of optical frequency which left only the predetermined intermediate frequency, It has an optical multiplexing means to multiplex said signal light and said local oscillation light, and a photo-electric-translation means to change and output the output of said optical multiplexing means to an electrical signal. The optical-heterodyne-detection section which outputs the modulating signal which inputted said signal light and carried out frequency conversion to said intermediate frequency, It has an unnecessary on-the-strength component clearance means to remove AM component in the signal which generates an optical frequency modulation means generated in said optical frequency modulation means. Said unnecessary on-the-strength component clearance means It is the modulation-technique conversion circuit characterized by consisting of a distribution means to distribute the electrical signal inputted into said optical frequency modulation means, and a multiplexing means to multiplex one of the outputs of said distribution means due to the output modulating signal of said optical-heterodyne-detection section, and an opposite phase.
[0008] Moreover, an optical frequency modulation means to output the signal light which invention according to claim 2 inputted the electrical signal, and carried out the optical frequency modulation, An optical frequency oscillation means to output said signal light and the local oscillation light of optical frequency which left only the predetermined intermediate frequency, It has an optical multiplexing means to multiplex said signal light and said local oscillation light, and a photo-electric-translation means to change and output the output of said optical multiplexing means to an electrical signal. The optical-heterodyne-detection section which outputs the modulating signal which inputted said signal light and carried out frequency conversion to said medium periphery </U> wave number, It has an unnecessary on-the-strength component clearance means to remove AM component in the signal which generates an optical frequency modulation means generated in said optical frequency modulation means. Said unnecessary on-the-strength component clearance means It is the modulation-technique conversion circuit characterized by consisting of a distribution means to distribute the electrical signal inputted into said optical frequency modulation means, and an optical intensity modulation means which carries out intensity modulation of the output signal light of said optical frequency modulation means with one output of said distribution means.
[0009] Moreover, an optical frequency modulation means to output the signal light which invention according to claim 3 inputted the electrical signal, and carried out the optical frequency modulation, An optical frequency oscillation means to output said signal light and the local oscillation light of optical frequency which left only the predetermined intermediate frequency, It has an optical multiplexing means to multiplex said signal light and said local oscillation light, and a photo-electric-translation means to change and output the output of said optical multiplexing means to an electrical signal. The optical-heterodyne-detection section which outputs the modulating signal which inputted said signal light and carried out frequency conversion to said intermediate frequency, It has an unnecessary on-the-strength component clearance means to remove AM component in the signal which generates an optical frequency modulation means generated in said optical frequency modulation means. Said unnecessary on-the-strength component clearance means Optical intensity modulation of one side of the output of a dichotomy means to dichotomize the output signal light of said optical frequency modulation means, and said dichotomy means is carried out. An optical intensity modulation means to supply the output which carried out optical intensity modulation to said optical-heterodyne-detection section, Another output of

said dichotomy means is changed into an electrical signal, and it is the modulation-technique conversion circuit characterized by consisting of an optical/electrical converter for inputting the changed electrical signal into said optical intensity modulation means as a modulating signal by the opposite phase.
[0010] Moreover, an optical frequency modulation means to output the signal light which invention according to claim 4 inputted the electrical signal, and carried out the optical frequency modulation, An optical frequency oscillation means to output said signal light and the local oscillation light of optical frequency which left only the predetermined intermediate frequency, It has an optical multiplexing means to compound said signal light and said local oscillation light, and the 1st photo-electric-translation means which changes and outputs the output of said optical multiplexing means to an electrical signal. The modulation-technique conversion circuit which consists of the optical-heterodyne-detection section which outputs the modulating signal which inputted said signal light and carried out frequency conversion to said intermediate frequency, The optical sending set which consists of a transmitting means to output the transmitting light which carried out intensity modulation with the output of said modulation-technique conversion circuit, In the lightwave signal transmission equipment which is connected to an optical transmission line and said optical sending set through said optical transmission line, and is equipped with the optical receiving set which consists of the 2nd photo-electric-translation means and a frequency recovery means which carries out the frequency recovery of the output of said 2nd photo-electric-translation means It has an unnecessary on-the-strength component clearance means to remove AM component in the signal which generates an optical frequency modulation means generated in said optical frequency modulation means. Said unnecessary on-the-strength component clearance means It is the lightwave signal transmission equipment characterized by consisting of a distribution means to distribute the electrical signal inputted into said optical frequency modulation means, and a multiplexing means to multiplex one of the outputs of said distribution means due to the output modulating signal of said optical-heterodyne-detection section, and an opposite phase. [0011] Moreover, an optical frequency modulation means to output the signal light which invention according to claim 5 inputted the electrical signal, and carried out the optical frequency modulation, An optical frequency oscillation means to output said signal light and the local oscillation light of optical frequency which left only the predetermined intermediate frequency, It has an optical multiplexing means to compound said signal light and said local oscillation light, and the 1st photo-electric-translation means which changes and outputs the output of said optical multiplexing means to an electrical signal. The modulation-technique conversion circuit which consists of the optical-heterodyne-detection section which outputs the modulating signal which inputted said signal light and carried out frequency conversion to said intermediate frequency, The optical sending set which consists of a transmitting means to output the transmitting light which carried out intensity modulation with the output of said modulation-technique conversion circuit, In the lightwave signal transmission equipment which is connected to an optical transmission line and said optical sending set through said optical transmission line, and is equipped with the optical receiving set which consists of the 2nd photo-electric-translation means and a frequency recovery means which carries out the frequency recovery of the output of said 2nd photo-electric-translation means It has an unnecessary on-the-strength component clearance means to remove AM component in the signal which generates an optical frequency modulation means generated in said optical frequency modulation means. Said unnecessary on-the-strength component clearance means It is the lightwave signal transmission equipment characterized by consisting of a distribution means to distribute the electrical signal inputted into said optical frequency modulation means, and an optical intensity modulation means which carries out intensity modulation of the output signal light of said optical frequency modulation means with one output of said distribution means.
[0012] Moreover, an optical frequency modulation means to output the signal light which invention according to claim 6 inputted the electrical signal, and carried out the optical frequency modulation, An optical frequency oscillation means to output said signal light and the local oscillation light of optical frequency which left only the predetermined intermediate frequency, It has an optical multiplexing means to compound said signal light and said local oscillation light, and the 1st photo-electric-translation means which changes and outputs the output of said optical multiplexing means to an electrical signal. The modulation-technique conversion circuit which consists of the optical-heterodyne-detection section which outputs the modulating signal which inputted said signal light and carried out frequency conversion to said intermediate frequency, The optical sending set which consists of a transmitting means to output the transmitting light which carried out intensity modulation with the output of said modulation-technique conversion circuit, In the lightwave signal transmission equipment which is connected to an optical transmission line and said optical sending set through said optical transmission line, and is equipped with the optical receiving set which consists of the 2nd photo-electric-translation means and a

frequency recovery means which carries out the frequency recovery of the output of said 2nd photo-electric-translation means It has an unnecessary on-the-strength component clearance means to remove AM component in the signal which generates an optical frequency modulation means generated in said optical frequency modulation means. Said unnecessary on-the-strength component clearance means Optical intensity modulation of one side of the output of a dichotomy means to dichotomize the output signal light of said optical frequency modulation means, and said dichotomy means is carried out. An optical intensity modulation means to supply the output which carried out optical intensity modulation to said optical-heterodyne-detection section, Another output of said dichotomy means is changed into an electrical signal, and it is the lightwave signal transmission equipment characterized by consisting of an optical/electrical converter for inputting the changed electrical signal into said optical intensity modulation means as a modulating signal by the opposite phase. [0013]

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[Embodiment of the Invention] As the example of 1 configuration is shown in drawing 1 (a) - drawing 1 (c), the lightwave signal transmission equipment with which this invention is applied extracts optical FM modulation component of the semi-conductor FM laser modulated with the broadband AM input signal as an electric FM modulation component by optical heterodyne detection, carries out intensity modulation of the light source for transmission, and transmits it to an optical transmission line. Drawing 1 (a) is the block diagram showing the whole lightwave signal transmission equipment 100 configuration. The lightwave signal transmission equipment 100 consists of SLT (subscriber line terminal)1, an optical transmission line 2, ONU (optical network termination) 3, and a television set 4. However, the television set 4 which receives AM video signal outputted from ONU3 can be transposed to devices, such as a video tape recorder which has a receive section. Furthermore, the configuration which does not contain a television set 4 can also be considered as one mode of the lightwave signal transmission equipment by this invention. In addition, the outline of such lightwave signal transmission equipment "Optical Super by the artificer of this application Wide-Band FM Modulation Scheme and Its Application to Multi-Channel AM Video Transmission Systems", International Conference on Integrated Optics It is indicated by and Optical FIbre Communication, IOOC-95, June 26-30, 1995, Technical Digest, and volume 5-Postdeadline Papers.
[0025] SLT1 shown in drawing 1 (a) consists of an AM/FM (amplitude modulation/frequency modulation) converter 11 and DFB (distribution feedback) laser 12. SLT1 inputs and transmits collectively AM video signal of the many channels by which frequency division multiplex was carried out to up to an optical transmission line 2 as an optical transmission signal by which intensity modulation was carried out with the multi-channel video signal changed and changed into FM video signal. An optical transmission line 2 transmits a lightwave signal using two or more optical fibers 22 connected to the branching output of an optical fiber 20, the optical star coupler 21, and the optical star coupler 21 with the passive double star (PDS) method which enables the communication link of one-pair a large number. ONU3 receives and carries out photo electric translation of the optical transmission signal transmitted through an optical transmission line 2 by photo electric translation and the FM/AM converter 30, and restores to it and outputs it to AM video signal. A television set 4 receives AM video signal outputted from ONU3, and projects the image of the channel of the arbitration chosen by the user from multiple channels.
[0026] Drawing 1 (b) is the block diagram showing the internal configuration of the AM/FM converter 11 shown in drawing 1 (a). The AM/FM converter 11 consists of the optical frequency modulation section 111 and the optical-heterodyne-detection section 112. The optical frequency modulation section 111 contains the semi-conductor FM laser 111-1. The optical-heterodyne-detection section 112 is equipped with the optical/electrical converter 112-3 which consists of the optical frequency local oscillator 112-1 and the optical multiplexing

machine 112-2 which consist of semi-conductor local laser 112-10, and PD (photodiode). On the other hand, photo electric translation and the FM/AM converter 30 consist of an optical/electrical converter 31 which consists of APD (ABARANSHU photodiode) as shown in drawing 1 (c), and the FM recovery section 32. FM recovery section 32 restores to FM electrical signal transformed into the electrical signal with the optical/electrical converter 31 to AM electrical signal by differentially coherent detection using the reversal non-inversed amplifier 32-1, the delay line 32-2, an exclusive "or" circuit 32-3, and a low pass filter 32-4.
[0027] The lightwave signal transmission equipment shown in drawing 1 by the above configuration inputs into SLT1 AM video signal of the many channels by which frequency division multiplex was carried out, and carries out FM modulation of the semi-conductor FM laser 111-1 with this input signal. Using the optical frequency local oscillator 112-1 and the optical multiplexing machine 112-2, with an optical-heterodyne-detection technique, the optical-heterodyne-detection section 112 obtains an optical frequency modulation component from the output of the semi-conductor FM laser 111-1 modulated with the broadband AM input signal, it carries out photo electric translation with an optical/electrical converter 112-3 further, and it extracts an electric package FM modulation component. Intensity modulation of the light source for transmission using DFB laser 12 is carried out by the electric package FM modulation component outputted from an optical/electrical converter 112-3, and the lightwave signal by which intensity modulation was carried out is transmitted to an optical transmission line 2. On the other hand, in a receiving side, photo electric translation of the optical transmission signal transmitted through an optical transmission line 2 is received and carried out with an optical/electrical converter 31 in ONU3. And in FM recovery section 32, it gets over to AM video signal by differentially coherent detection.
[0028] The spectrum of the recovery multi-channel AM video signal to which bundles up an example of the spectrum of the electric package FM modulation component obtained by drawing 2 (a) as an output of the optical-heterodyne-detection section 112 by FM recovery section 32 to drawing 2 (b), and it restores is shown. Drawing 2 (a) shows the center frequency of the spectrum of an electric package FM modulation component, and the intermediate frequency shows the case of 1.75GHz. Drawing 2 (b) shows the case where it restores to AM video signal of 40 channels.
[0029] When applying the lightwave signal transmission equipment of a configuration of being shown in drawing 1 (a) -1(c) to a cable television system, it becomes possible to put in block AM video signal of dozens of channels, to change into one FM signal, to send this out to an optical transmission line, to put this FM transmission signal in block by differentially coherent detection etc. by the receiving side, and to get over to a multi-channel AM video signal. That is, according to the above configuration, with the package FM-TV transmission system which used VCO conventionally, the signal transmission of the difficult wide band of realizing becomes possible. However, in order in using lightwave signal transmission equipment mentioned above to decrease a noise and to make a quality signal transmission possible, to adopt each configuration by this invention explained further below in addition to the above configuration is desired.
[0030] In the package FM-TV transmission system with which the configuration shown in drawing 1 (a) and drawing 1 (c) is included, it turns out that the value of CNR (Carrier to Noise Ratio: carrier-to-noise ratio) obtained when it restores to the output signal in the photo electric translation in ONU3 and the output terminal (namely, output terminal of FM recovery section 32) of the FM/AM converter 30 to AM video signal is dependent on the number of channels to transmit. That is, CNR can be improved by reducing the number of channels. However, when the number of channels is reduced for the purpose of the improvement of CNR, the operation effectiveness of the signal transmission of the wide band obtained by the above-mentioned configuration is no longer employed fully efficiently. Therefore, a technique which can perform the improvement of CNR was desired, without reducing the number of channels. On the other hand, this invention sets it as the detailed object to offer the modulation-technique conversion circuit which can improve CNR, and lightwave signal transmission equipment, without reducing the number of channels, and offers the configuration for it.
[0031] the ratio of the power PFM of the signal light (FM laser beam) inputted into an optical/electrical converter 112-3 in the optical-heterodyne-detection section 112 which shows drawing 3 (a) and drawing 3 (b) to drawing 1 (b), and the power PLO of the local oscillation light (local laser beam) outputted from the optical frequency local oscillator 112-1 -- the relation of PFM/PLO and CNR when restoring to a modulating signal to AM video signal in the output terminal of the AM/FM converter 11 is shown. Here, drawing 3 (a) shows measured value in case it is 2.75GHz, the center frequency, i.e., the intermediate frequency, of FM signal spectrum, and, as for drawing 3 (b), shows the measured value in 3.85GHz. Both are the transmission characteristics of 20 channels. Moreover, frequency deviation deltaf per channel is 220MHz0-p/ch and 280MHz0-p/ch, respectively, when intermediate frequencies are 2.75GHz and 3.85GHz.

[0032] As shown in these drawings, CNR of AM video signal changes depending on the value of the ratios PFM/PLO of the power PFM of FM laser beam, and the power PLO of a local laser beam. Furthermore, the relation between CNR and the power ratios PFM/PLO changes with the magnitude of an intermediate frequency. Moreover, as for CNR serving as max, drawing 3 (a) and drawing 3 (b) show that an optical power ratio is about 0dB. therefore, the ratio of Power PFM and Power PLO -- it becomes possible by controlling PFM/PLO in the range of desired to obtain desired CNR.
[0033] By the way, the specification of the transmission quality in the same axle CATV about current and CNR is 42dB or more. Moreover, if in charge of controlling the power ratios PFM/PLO actually, it is necessary to expect about **4dB of initial manufacture deflection to a design value about the power PFM of FM laser beam, and each power PLO of a local laser beam. Therefore, if it thinks in consideration of these conditions based on the property shown in drawing 3 (a) and drawing 3 (b), in order to acquire the property of CNR which is the stable quality and satisfies 42dB or more of specification of the transmission quality, it is desirable to control the ratio of PFM/PLO to -8<PFM/PLO<8[dB].
[0034] Next, other operation gestalten by this invention of the AM/FM converter 11 of the lightwave signal transmission equipment shown in drawing 1 (a) and drawing 1 (b) are explained to the drawing 2 (a) list with reference to drawing 4 - drawing 8. In the optical frequency modulation section 111 shown in drawing 1 (b) mentioned above, the optical frequency modulation is applied to FM laser beam outputted by changing the inrush current of the FM laser 111-1 constituted by semiconductor laser according to an input signal. However, in an optical heterodyne output, since optical intensity modulation also starts FM laser beam by change of an inrush current in this case, as shown in the electric package FM modulating-signal spectrum of drawing 2 (a), an AM component will be simultaneously intermingled not only in FM component. On the other hand, it is ideal FM modulation that the spectrum becomes a symmetry form focusing on an intermediate frequency (the example of drawing 2 (a) 1.75GHz) about FM modulation component. However, since not only frequency modulation but intensity modulation starts FM laser beam simultaneously actually, a spectrum becomes unsymmetrical. Moreover, there is fluctuation in the amplitude of FM laser beam or a local laser beam, and since these will become distortion and a noise if it gets over by FM recovery section 32, they have a possibility of becoming the cause by which image quality makes it deteriorate. Moreover, since fluctuation of the optical frequency of FM laser beam and fluctuation of the optical frequency of a local laser beam will also become a noise too if it gets over by FM recovery section 32, they have a possibility of becoming the cause by which image quality deteriorates. Then, the operation gestalt by this invention shown below aims at the cure, and makes possible a quality signal transmission with still few distortion and noises.
[0035] Drawing 4 shows other operation gestalten by this invention of AM / FM converter 11 shown in drawing 1 (a). The same sign is attached to the same thing as the configuration shown in drawing 1 (a) or drawing 1 (b) in drawing 4. In addition, in other operation gestalten shown below, the same sign is similarly attached to the same configuration. AM/FM converter 11B shown in this drawing Differential distributor 11B-1 which 180 degrees of phases of an input AM video signal are changed, and distributes them, Amplitude regulator 11B-2 which input one electrical signal between two outputs of differential distributor 11B-1, and adjust the amplitude, It newly has inphase composition machine 11B-4 which are in phase and compound time delay regulator 11B-3 which give delay to the output electrical signal of amplitude regulator 11B-2, the output electrical signal of time delay regulator 11B-3, and the electric package FM modulation component based on the output of another side of differential distributor 11B-1. In AM/FM converter 11B, differential distributor 11B-1 distributes a phase for AM video signal due to an opposite phase (0 degree and 180 degrees), one output (phase; 0 degree) is inputted into the FM laser 111-1, and the output is supplied to the optical-heterodyne-detection section 112. The optical-heterodyne-detection section 112 carries out optical heterodyne detection of the inputted lightwave signal, further, by PD 112-3, is changed into an electrical signal and outputs a frequency modulation signal. Inphase composition of the electrical signal outputted from PD 112-3 and the electrical signal based on another output (phase; 180 degrees) of differential distributor 11B-1 is carried out by inphase composition machine 11B-4. At this time, amplitude adjustment is carried out by amplitude regulator 11B-2, and time delay adjustment of the electrical signal inputted into inphase composition machine 11B-4 from phase the side of 180 degrees is further carried out by time delay regulator 11B-3 so that the AM component of optical frequency modulating-signal light and the amplitude of tales doses may make an opposite phase. Therefore, each input signal of inphase composition machine 11B-4 offsets each AM component in inphase composition machine 11B-4. The spectrum of the output of PD 112-3 was shown in (1), and the spectrum of the output of time delay regulator 11B-3 was shown in (2) among drawing. In addition, although the configuration which distributes an opposite phase

component and performs inphase composition was shown, it can be in phase, can distribute and can also change into the configuration which performs differential composition here. This modification is possible similarly in the operation gestalt shown in drawing 7 described later or drawing 11.
[0036] the ratio of the power PFM of signal light (FM laser beam) and the power PLO of a local laser beam which are inputted into the optical/electrical converter 112-3 in AM/FM converter 11B shown in drawing 4 with reference to drawing 5 (a) and drawing 5 (b) here -- with PFM/PLO When it restores to an electric package conversion FM signal in the output terminal of inphase composition machine 11B-4 The relation between the secondary compound distortion of a ** AM video signal (CSO:Composite Second-Order Distortion) and 3rd compound distortion (CTB:Composite Triple Beat Distortion) is explained.
[0037] As for measured value in case it is 2.75GHz, the center frequency, i.e., the intermediate frequency, of FM signal spectrum, and drawing 5 (b), drawing 5 (a) shows the measured value in 3.85GHz, respectively. And both of the drawings show the transmission characteristic of 20 channels. In drawing 5 (a) and 5 (b), the property shown as a continuous line is the property of the AM/FM converter 11 shown in drawing 1 (b), and the property shown with a broken line is the property of AM/FM converter 11B shown in drawing 4. In addition, frequency deviation deltaf per channel is 220MHz0-p/ch and 280MHz0-p/ch, respectively, when intermediate frequencies are 2.75GHz and 3.85GHz. Thus, according to the configuration shown in drawing 4, by the case where it is shown in drawing 5 (a), CSO can be improved by removing AM component, not changing the value of PFM/PLO, as an arrow head shows. Moreover, in the case of drawing 5 (b), both CSO and CTB can be improved, not changing the value of PFM/PLO, as an arrow head shows. Therefore, it is possible to improve both CNR and distortion (CSO, CTB) by applying AM component clearance and the control of the predetermined range of an optical power ratio mentioned above.
[0038] Drawing 6 is the block diagram showing other configurations of the operation gestalt for carrying out AM component clearance like AM/FM converter 11B explained with reference to drawing 4. Optical-heterodyne-detection section 112C consists of AM/FM converter 11C shown in drawing 6 using optical/electrical converter 112C-3 considered as the balance DORESHIBA configuration. In optical-heterodyne-detection section 112C, optical/electrical converter 112C-3 consist of two PDs which corresponded, and the optical path length from the optical multiplexing machine 112-2 to two PDs is in agreement. In this case, in optical/electrical converter 112C-3, the amount of on-the-strength strange preparation is in phase, it is received, and a frequency modulation component is received by the opposite phase. Since optical/electrical converter 112C-3 are constituted so that each polarity of two PDs may become reverse mutually, a part for on-the-strength strange preparation is offset, and a frequency modulation component is added there.
[0039] In this case, one of the features of considering as a balance DORESHIBA configuration is the point which can also offset a part for a part for the on-the-strength strange preparation of FM laser beam, and the on-the-strength strange preparation of not only fluctuation on the strength but a local laser beam, and fluctuation on the strength. Another features are that it uses both of the outputs of the optical multiplexing machine 112-2 which consists of a directional coupler. Since according to this a frequency modulation component is added as mentioned above, optical power can be used effectively. In addition, balance DORESHIBA is explained to the following reference Kiyoshi Nosu, Katsushi Iwashita, and Nori Shibata, Masao Kawachi, Hiromu Toba, Osamu Ishida, Takeshi Ito, and Kyo Inoue, "Coherenct Lightwave Communications Technology", pp.76-79, Chapman & Hall, London, and 1995 in detail, for example.
[0040] When the configuration of drawing 4 is compared with the configuration of drawing 6, the configuration of drawing 4 has the advantage of being cheap, compared with the configuration of drawing 6 which used balance DORESHIBA. All of differential distributor 11B-1 used, amplitude regulator 11B-2, and time delay regulator 11B-3 should just operate below the more than frequency of a multi-channel video signal, for example, 0MHz, and 350MHz, and it is because the electronic parts used are cheap. Although it is inphase composition machine 11B-4 used as high frequency (frequency of a package FM signal), it is cheap too that is not uniquely cheap, if compared with balance DORESHIBA. On the other hand, since the optical/electrical converters (PD) which operate by the RF are 2 need, balance DORESHIBA becomes expensive as compared with the configuration shown in drawing 4. In the conventional lightwave signal transmission system, across the long optical transmission line, the optical transmitting section (configuration corresponding to SLT1 shown in drawing 1 (a)) and an optical receive section (configuration corresponding to ONU3 shown in drawing 1 (a)) separate, and are usually established. It is desirable to perform optical heterodyne detection with such a configuration only using the lightwave signal which has passed through the long optical transmission line in an optical receive section. In such a configuration, balance DORESHIBA is used in order to acquire a quality recovery signal.

[0041] On the other hand, AM component clearance of the configuration of drawing 4 is carried out using the output of an optical/electrical converter 112-3, and the electrical signal based on the modulating signal of the FM laser 111-1. When it is going to adopt this configuration, in the conventional configuration, it will be necessary to lay the signal-transmission way for AM components independently, or to install new equipment in a receive section. Since each components 112-10,112-2,112-3 of all that constitute the FM laser 111-1 and the optical-heterodyne-detection section 112 from a configuration of AM/FM converter 11B shown in drawing 4 by this invention are installed in SLT1 of a transmitting side and it is in point-blank range, it is possible to compound the electrical signal and the output electrical signal of the optical-heterodyne-detection section 112 which distributed the input to the FM laser 111-1 with a simple configuration. Therefore, it is possible to employ efficiently the advantage of being cheaper than the configuration using difficult balance DORESHIBA, with the conventional configuration.
[0042] On the other hand, the advantage of the configuration using balance DORESHIBA shown in drawing 6 is the point that the component on the strength which can be offset can contain not only the thing of FM laser but the thing of local laser. However, since the distance between the FM laser 111-1 and PD 112-3 can make low local oscillation light power (output of the local laser 112-2) also in a configuration like drawing 4 about this point when it be comparatively short, it be expectable by make small effect of fluctuation on the strength of a local laser beam to acquire the same property as the case where balance DORESHIBA be use.
[0043] Next, other modifications of AM/FM converter 11B shown in drawing 4 with reference to drawing 7 are explained. In addition to each configuration of differential distributor 11B-1 with which AM/FM converter 11B shown in drawing 4 is equipped, amplitude regulator 11B-2, time delay regulator 11B-3, and the optical-heterodyne-detection section 112, AM/FM converter 11D shown in drawing 7 has optical intensity modulator 11C-6 which newly carry out optical intensity modulation of the FM laser beam with the output of time delay regulator 11B-3. With this operation gestalt, the input of the FM laser 111-1 is dichotomized at 0 degree and 180 degrees by actuation distributor 11B-1, intensity modulation of the lightwave signal by the side of 0 degree is carried out using the signal by the side of 180 degrees, and an AM component is offset.
[0044] Drawing 8 is the block diagram showing other modifications of AM/FM converter 11B shown in drawing 4. In AM/FM converter 11E shown in drawing 8 The output of the FM laser 111-1 The output of amplitude controller 11C-3 which adjust the amplitude and time delay of PD11C-2 which change one dichotomous output light of optical turnout 11C-1 and optical turnout 11C-1 into an electrical signal, and the output electrical signal of those and time delay regulator 11C-4, and time delay regulator 11C-4 Phase-inverter 11C-5 to reverse and optical intensity modulator 11C-6 which carry out optical intensity modulation of another output light of optical turnout 11C-1 with the output of phase-inverter 11C-5 are newly prepared. And in AM/FM converter 11E, the output light of optical intensity modulator 11C-6 was detected in the optical-heterodyne-detection section 112, and the electric package FM modulation component has been obtained.
[0045] In AM/FM converter 11E shown in drawing 8 The optical frequency modulating-signal light modulated by the input AM video signal in the FM laser 111-1 is dichotomized by optical turnout 11C-1. By inputting into optical intensity modulator 11C-6 by the opposite phase eventually, and carrying out intensity modulation of other output light of optical turnout 11C-1, after inputting one side into optical intensity modulator 11C-6 and changing another side into an electrical signal by PD11C-2 The AM component of the output light of optical intensity modulator 11C-6 is offset. In this case, in amplitude regulator 11C-3 and time delay regulator 11C-4, the amplitude and phase of the electrical signal inputted into optical intensity modulator 11C-6 are adjusted so that an AM component may be offset and the spectrum of FM modulation component may serve as a symmetry form as much as possible focusing on an intermediate frequency. With the operation gestalt shown in drawing 7 and drawing 8, an AM component is offset in the state of the lightwave signal which was sent out from the FM laser 111-1 with the output which carried out photo electric translation using PD like the operation gestalt shown in the configuration using balance DORESHIBA shown in drawing 6, or drawing 4 unlike having offset the AM component. In a configuration of having been shown in the configuration using balance DORESHIBA or drawing 4, the AM component or the fluctuation on the strength which are included in an intermediate frequency cannot be offset. On the other hand, with the configuration of drawing 7 and drawing 8, since the AM component is offset in the phase of light, the fluctuation on the strength of an AM component or FM laser can be offset covering all the frequencies of the output of PD. It corrects, Since the configuration of drawing 7 and drawing 8 cannot set off the local oscillation luminous-intensity fluctuation of the local laser 112-10 against there being an inclination which becomes expensive since components mark increase, about this point, it can be said that the direction of the operation gestalt shown in drawing 6 is excellent.

[0046] In addition, with the operation gestalt shown in drawing 8, although phase-inverter 11C-5 are used, since it can be made reversed with the polarity of PD11C-2, when it is made such, phase-inverter 11C-5 can be omitted. This is the same also with the operation gestalt shown in drawing 13 described later.
[0047] Drawing 9 and drawing 10 are the block diagrams showing other operation gestalten of the lightwave signal transmission equipment by this invention. With the operation gestalt shown in drawing 9 and drawing 10, after superimposing a pilot signal on a broadband AM input signal, semi-conductor FM laser is modulated. And two band pass filter 11E-1 and 11E-2 extract FM modulating signal and the pilot signal which were acquired by optical heterodyne detection, and they carry out frequency-mixing by frequency mixer 11E-3 further. According to the operation gestalt, the noise resulting from the fluctuation component of the frequency of semi-conductor FM laser and the frequency fluctuation component of the laser for local oscillation is removable with this. As compared with the lightwave signal transmission equipment 100 shown in the lightwave signal transmission equipment 101 shown in drawing 9 at drawing 1, the multiplexing machine 5 which carries out frequency multiplex [of the pilot signal with which frequencies differ in AM video signal] is newly formed. The output of this multiplexing machine 5 is inputted into SLT1F. In addition, about offset of the fluctuation component by using a pilot signal, it is advocated with the following reference [reference:Y.H.Cheng, T.Okoshi, "Phase-noise-cancelling dual-frequency heterodyne optical fibre communication system", Electronics Letter, vol.25, no.13, pp.835-836, and 1989.].
[0048] Here, the detail of actuation of AM/FM converter 11K is explained using drawing 14. Drawing 14 shows the spectrum in (G) from each part (A) in each operation gestalt shown in drawing 10 and drawing 11 mentioned later, drawing 12, and drawing 13. In drawing 9, the multiplexing machine 5 carries out frequency multiplex [of the pilot signal] to AM video signal. Here, it is assumed that it is that from which the electrical signal with which frequency multiplex [of AM video signal with a frequency of 90MHz - 450MHz and the frequency fp=2.1GHz pilot signal] was carried out is acquired as an output (A) of the multiplexing machine 5 as an example ((A) of drawing 14). The optical frequency modulation section 111 shown in drawing 10 outputs the optical frequency modulating signal which carries out optical FM modulation of the FM laser 111-1 according to the inrush current according to the electrical signal (A) inputted from the multiplexing machine 5, for example, sets center frequency f1 to 193,006.1 GHz ((B) of drawing 14). In the output (B) of the optical frequency modulation section 111, the frequency component which fluctuation **f1 by the FM laser 111-1 generated to the intermediate frequency f1 of FM modulating signal, and the lightwave signal containing frequency component f1**fp (193,004. 0 GHz and 193,008.2 GHz) of a pilot signal which has fluctuation **f1 similarly again appear.
[0049] It uses the local oscillation light (C) from the optical frequency local oscillator 112-1 shown in (C) of drawing 14, and the optical-heterodyne-detection section 112 (may be local oscillation optical frequency f2=193,000GHz here) by considering optical frequency modulating-signal light (B) from the optical frequency modulation section 111 as an input, and the electrical signal which detected by performing optical heterodyne detection is outputted from an optical/electrical converter 112-3. (D) of drawing 14 shows the spectrum of electric FM package modulation component (D) outputted from an optical/electrical converter 112-3. Since the output of the optical frequency local oscillator 112-1 is the local oscillation light of the local laser 112-10 and the oscillation frequency f2 has become what swung by fluctuation component **f2 Electric FM package modulation component (D) becomes what swung by fluctuation **f (=**f1+**f2) further from the main oscillation frequency f1 of the FM laser 111-1 about the center frequency as f1-f2 which subtracted the local oscillation frequency f2. Moreover, electric FM package modulation component (D) contains the frequency component of f1-f2**fp by the pilot signal simultaneously. In this case, electric FM package modulation component (D) serves as a signal containing each frequency component (center frequency f1-f2=6.1GHz, f1-f2**fp=8.2GHz by the pilot signal, and 4.0GHz).
[0050] The fluctuation of the optical frequency of optical frequency modulating-signal light (B) and local oscillation light (C) is changed into fluctuation of an electrical signal (D) as it is. Moreover, fluctuation of the electric frequency of a package FM modulation component and the fluctuation of the electric frequency of a pilot signal become identitas (**f=**f1+**f2). The results of having taken out the package FM modulation component (D) and a round wave number component of a pilot signal using band pass filter 11E-1 and 11E-2, respectively are (E) of drawing 14, and (F). If frequency-mixing of these is carried out by frequency mixer 11E-3, the electrical signal (G) which makes center frequency against which the fluctuation component was set off the frequency fp of a pilot signal can be taken out from frequency mixer 11E-3 ((G) of drawing 14).
[0051] Drawing 11 is the block diagram showing another configuration of AM/FM converter 11K in SLT1F shown in drawing 9. In AM/FM converter 11F, the signal which superimposed the pilot signal on AM image input signal

by differential distributor 11B-1 Distribute a phase due to an opposite phase (0 degree and 180 degrees), and the output (phase; 0 degree) of one of these is inputted into the optical frequency modulation section 111. Inphase composition of another [the electrical signal outputted from the optical-heterodyne-detection section 112 and] output (phase; 180 degrees) of differential distributor 11B-1 is carried out by inphase composition machine 11B-4. The output by which inphase composition was carried out dichotomizes and is divided into FM signal modulation component and a pilot signal by two band pass filter 11E-1 and 11E-2, respectively. Frequency-mixing of these [which were separated] two electrical signals is carried out by the multiplier in E-frequency mixer 113. As mentioned above, fluctuation of the optical frequency of optical frequency modulating-signal light and local oscillation light is offset by performing frequency-mixing. According to AM/FM converter 11F shown in drawing 11, the clearance effectiveness of the fluctuation component by using a pilot signal and the effectiveness of offset of the same AM component as the operation gestalt shown in drawing 4 can be doubled and acquired.
[0052] Drawing 12 is drawing showing other operation gestalten of AM/FM converter 11K shown in drawing 9. AM/FM converter 11G shown in drawing 12 are equipped with the optical frequency modulation section 111 and optical-heterodyne-detection section 112C which are constituted like AM/FM converter 11C shown in drawing 6, and prepare frequency mixer 11E-3 which mix band pass filter 11E-2 and those outputs for extracting band pass filter 11E-1 and the pilot signal for newly extracting FM modulating-signal component. In AM/FM converter 11G, the FM laser 111-1 is modulated with the electrical signal which superimposed the pilot signal on AM image input signal. And by balance DORESHIBA 112C-3, optical heterodyne detection of the output light of the FM laser 111-1 is carried out, it dichotomizes, the detection output is inputted into two band pass filter 11E-1 and 11E-2, and it separates into FM signal modulation component and a pilot signal. Frequency-mixing of these [which were furthermore separated] two electrical signals is carried out by frequency mixer 11E-3, and fluctuation of the optical frequency of optical frequency modulating-signal light and local oscillation light is offset. According to the operation gestalt shown in this drawing, the effectiveness which offsets the same part for the on-the-strength strange preparation of FM laser beam and fluctuation on the strength as the clearance effectiveness of the fluctuation component by using a pilot signal and the operation gestalt shown in drawing 6, and a part for the on-the-strength strange preparation of a local laser beam and fluctuation on the strength can be doubled and acquired.
[0053] Drawing 13 is drawing showing other operation gestalten of AM/FM converter 11K shown in drawing 9. AM/FM converter 11H shown in drawing 13 modulate the FM laser 111-1 with the electrical signal which superimposed the pilot signal on AM image input signal. It dichotomizes by optical turnout 11C-1, and one side is inputted into optical intensity modulator 11C-6, and another side is inputted into PD11C-2, and the optical frequency modulating-signal light outputted from the FM laser 111-1 is changed into an electrical signal, and is further inputted into optical intensity modulator 11C-6 by the opposite phase through amplitude regulator 11C-3, time delay regulator 11C-4, and phase-inverter 11C-5. By carrying out intensity modulation of the lightwave signal inputted into optical intensity modulator 11C-6 with the electrical signal outputted from phase-inverter 11C-5, the AM component in the output light of optical intensity modulator 11C-6 is offset. It dichotomizes, the detection output (D) which carried out optical heterodyne detection of this output light of optical intensity modulator 11C-6 is inputted into two band pass filter 11E-1 and 11E-2, and it separates into FM signal modulation component (E) and a pilot signal (F). And frequency-mixing of these [which were separated] two electrical signals is carried out by frequency mixer 11E-3, and fluctuation of the optical frequency of optical frequency modulating-signal light and local oscillation light is offset. According to the operation gestalt shown in drawing 13, the clearance effectiveness of the fluctuation component by using a pilot signal and the effectiveness which offsets the fluctuation on the strength of the same AM component as the operation gestalt shown in drawing 8 or FM laser can be doubled and acquired.
[0054] Each operation gestalt of this invention mentioned above, without being restricted to the above-mentioned gestalt in addition, for example, as other operation gestalten It changes to AM/FM converter 11K shown in drawing 9. It is possible to use the configuration which adds band pass filter 11E-1 as further shown in the output of the optical/electrical converter 112-3 of AM/FM converter 11D shown in drawing 7 drawing 11 - 13 and 11E-2, and frequency mixer 11E-3 etc.
[0055] Next, with reference to drawing 15 (a) and drawing 15 (b), other operation gestalten of the lightwave signal transmission equipment by this invention are explained. The lightwave signal transmission equipment 102 shown in drawing 15 (a) consists of the PURIDISU torsion circuit 6 established in the preceding paragraph of SLT1J, SLT1J, an optical transmission line 2, an attenuator 7, ONU3J, and a television set 4. SLT1J consist of

AM/FM converter 11J, semiconductor laser 12, such as a DFB laser, and light amplifiers 13, such as erbium dope fiber amplifier. ONU3J consist of FM recovery section 32J with the optical photo detectors 31, such as APD. In addition, AM/FM converter 11J and FM recovery section 32J are constituted like the operation gestalt explained with reference to each drawing mentioned above like the AM/FM converter 11 shown in drawing 1, and FM recovery section 32. In the lightwave signal transmission equipment 102 shown in drawing 15 (a), distortion is offset by compounding beforehand the distortion of the amount and tales doses of distortion carrying out distortion compensation in the PURIDISU torsion circuit 6 in a latter circuit by the opposite phase. The PURIDISU torsion circuit 6 can consist of FET amplifier etc. that what is necessary is just to operate by the frequency band of AM video signal, for example, 90MHz, to 280MHz rather than to operate to broadband FM signal.
[0056] Drawing 15 (b) is the block diagram showing the example of 1 configuration of the PURIDISU torsion circuit 6. The PURIDISU torsion circuit 6 shown in drawing 15 (b) consists of a turnout 61, the distortion generating circuit 62, an adjustable attenuator 63, the adjustable delay line 64, and a multiplexing machine 65. The inputted multi-channel AM video signal dichotomizes by the turnout 61, and is inputted into the distortion generating circuit 62 as the noninverting input of the multiplexing machine 65. The distortion generating circuit 62 gives a predetermined distortion to an input signal, and the adjustable attenuator 63 and the adjustable delay line 64 adjust the reinforcement and the phase of a signal further. And the signal outputted from the adjustable delay line 64 is inputted into the reversal input of the multiplexing machine 65, and it is multiplexed with another [which branched by the turnout 61] signal.
[0057] The operation acquired by the PURIDISU torsion circuit 6 mentioned above is compensating distortion produced in AM/FM converter 11J. However, by changing distortion which the PURIDISU torsion circuit 6 gives to an input signal, it can also compensate including distortion further produced in FM recovery section 32J of ONU3J, and it is also possible to include and compensate even distortion further produced by the optical-fiber-transmission way 2. In addition, as a factor of distortion produced in AM/FM converter 11J, the nonlinearity in the dynamic characteristics of the input current pair output optical frequency property of FM laser can be considered. Moreover, the group-delay deflection of the electric amplifier used in AM/FM converter 11J is considered as other factors. On the other hand, as distortion produced in FM recovery section 32J in ONU3J, the group-delay deflection of the electric amplifier which constitutes it is the factor whose number is one, and the nonlinearity of the input frequency pair output voltage property of FM recovery section 32J is also further considered as other factors. Moreover, as a factor of distortion produced by the optical-fiber-transmission way 2, distribution of the optical fiber for transmission is one factor. Therefore, what is necessary is for distortion given to an input signal in the PURIDISU torsion circuit 6 to search for these factors beforehand by count or experiment, and to change it suitably according to other factors, such as an input signal and temperature, if needed further, to set up and just to adjust it so that it may be compensated.
[0058] In addition, although this operation gestalt explained the multi-channel AM video signal as an input signal, it can explain similarly the multi-channel QAM video signal by which frequency division multiplex was carried out as an input. Moreover, the analog except a video signal or digital one can explain a broadband electrical signal similarly as an input.
[0059] In addition, although it has inputted into ONU3J with the operation gestalt shown in drawing 15 (a) after it outputs after forming the erbium dope fiber amplifier 13 in the output stage of SLT1J and amplifying the output light of DFB laser 12, and making it decrease with an attenuator 7, arrangement or the number of amplifier or an attenuator do not need to be limited to the mode of this operation gestalt. Moreover, omitting suitably is possible.
[0060] Next, other operation gestalten of the AM/FM converter by this invention are explained with reference to drawing 16 (a) and drawing 16 (b). Drawing 16 (a) and drawing 16 (b) show the block diagram of the AM/FM converter as a modification of the AM/FM converter 11 shown in drawing 1 (b), respectively. The operation gestalt shown in drawing 16 (a) and drawing 16 (b) is characterized by reducing the optical frequency fluctuation of an electric package FM signal by AFC (Auto Frequency Controller: automatic frequency control circuit)202. Optical frequency fluctuation results from fluctuation of the oscillation optical frequency of the FM laser 111-1, and fluctuation of the oscillation optical frequency of the local laser 112-10. A low pass filter 201 extracts the fluctuation component of the optical frequency of the low frequency within FM recovery signal inputted through PD204, FM recovery section 203, and AFC202. In this case, the input light of PD204 is taken out from one outgoing end of the vacant (it does not connect with PD 112-3) optical turnout 112-2. According to the fluctuation component extracted with the low pass filter 201, the negative feedback control of the optical

frequency of the FM laser 111-1 (in the case of drawing 16 (a)) or the local laser 112-10 (in the case of drawing 16 (b)) is carried out. As an approach of carrying out a negative feedback control, there is a method of changing the inrush current to the FM laser 111-1 or the local laser 112-10 or a method of changing the temperature.
[0061] In addition, although this operation gestalt explained the multi-channel AM video signal as an input signal, it can explain similarly the multi-channel QAM video signal by which frequency division multiplex was carried out as an input. Moreover, . analog except a video signal or digital one can explain a broadband electrical signal similarly as an input. According to this operation gestalt shown in drawing 16 (a) and drawing 16 (b), the noise generated by optical frequency fluctuation of FM signal which carried out package conversion can be reduced.
[0062] In addition, each operation gestalt explained with reference to drawing 15 (a) and drawing 15 (b) or drawing 16 (a), and drawing 16 (b) The AM/FM converters 11L, 11M, 11N, and 11O shown in drawing 17, drawing 18, drawing 19, and drawing 20, for example, without being limited to the combination shown in those drawings, It is possible to combine with the lightwave signal transmission equipment or the AM/FM converter explained with reference to drawing 1 - drawing 14 suitably. In addition, the same sign as what was used with the above-mentioned operation gestalt is attached to each component shown in drawing 17 - drawing 20, and explanation is omitted.
[0063] Moreover, it is possible to combine the configuration which removes an unnecessary component on the strength using the signal with which drawing 4, drawing 6, and drawing 7 differ from a phase as shown in drawing 8 in addition to this, and the configuration which offsets frequency fluctuation using a pilot signal as shown in drawing 10 - drawing 13, and to combine with them the configuration which reduces distortion by the PURIDISU torsion circuit further shown in drawing 15 (a) and drawing 15 (b). Moreover, it is possible to combine the configuration which removes an unnecessary component on the strength using the signal with which drawing 4, drawing 6, and drawing 7 differ from a phase as shown in drawing 8, and the configuration which reduces distortion by the PURIDISU torsion circuit shown in drawing 15 (a) and drawing 15 (b), and to combine with them the configuration which reduces optical frequency fluctuation by AFC further shown in drawing 16 (a) and drawing 16 (b).
[0064]
[Effect of the Invention] As explained above, according to this invention,-izing of the frequency band can be carried out [broadband] compared with the former, and the lightwave signal transmission equipment using the modulation-technique conversion circuit and it which make possible a quality signal transmission with few noises can be obtained.
[0065] An optical frequency modulation means to input an electrical signal and to output in more detail the signal light which carried out the optical frequency modulation according to invention according to claim 1 to 3, The optical-heterodyne-detection section which outputs the modulating signal which inputted signal light and carried out frequency conversion to the intermediate frequency, Since it has an unnecessary on-the-strength component clearance means to remove AM component in the signal which generates an optical frequency modulation means generated in said optical frequency modulation means AM component intermingled in optical frequency modulating-signal light can be removed, and an intermediate frequency can be made into type FM modulated wave symmetrical as a core for the spectrum of FM modulation component. Moreover, the noise on the strength made from the amplitude fluctuation of optical frequency modulating-signal light or local oscillation light is removable. Moreover, the frequency fluctuation of FM modulation component produced from fluctuation of optical frequency modulating-signal light is removable. Moreover, although the optical transmission device by this invention is especially used for transmission of a multi-channel video signal and is effective, it may be used also for transmission of other signals and can make possible a quality signal transmission with few distortion and noises.
[0066] Moreover, according to invention according to claim 4 to 6, the lightwave signal transmission equipment which can acquire the same effectiveness as it is obtained by invention according to claim 1 to 3 can be offered.
[0067]
[0068]
[0069]
[0070]
[0071]
[0072]

[Translation done.]

TECHNICAL FIELD

[Field of the Invention] This invention relates to the modulation-technique conversion circuit and lightwave signal transmission equipment which are used for the optical transmission of a broadband signal. This invention relates to the modulation-technique conversion circuit and lightwave signal transmission equipment which were suitable for carrying out optical transmission of the multi-channel video signal by which frequency division multiplex is carried out, and by which amplitude modulation was carried out, and were suitable for using by the passive double star (PDS) light subscriber system especially in more detail.

[Translation done.]

PRIOR ART

[Description of the Prior Art] In current and each country, researches and developments of the optical transmission method which changes and transmits a broadband electrical signal to a lightwave signal as an approach of transmitting a multi-channel video signal are furthered energetically. There is a method (henceforth an AM-TV transmission system) which carries out intensity modulation of the semiconductor laser to one of them in proportion to the amplitude of the multi-channel video signal by which amplitude modulation is carried out, and carries out optical transmission of the lightwave signal which carried out intensity modulation to it. The AM-TV transmission system is mainly used for the trunk system optical transmission of cable television. However, since an AM-TV transmission system has small noise proof stress, it has the technical problem that the large level difference between transmission and reception cannot be taken, and the large transmission distance and the optical large degree in an optical transmission system cannot be taken.
[0003] In order to solve this technical problem, after carrying out the frequency modulation of the multi-channel video signal beforehand for every channel, the method (henceforth the FM-TV transmission system according to image channel individual) which carries out intensity modulation of the semiconductor laser, and carries out optical transmission was developed. Since the FM-TV transmission system according to image channel individual has large noise proof stress, it can take a transmission distance and an optical large degree in the big optical transmission system of the level difference between transmission and reception. However, by this method, since it must get over after choosing a channel, and a channel selection circuitry will become complicated in a broadband, the technical problem that a receiver will become expensive occurred.
[0004] On the other hand, after the multi-channel video signal was put in block with many channels and carried out frequency modulation as a different thing from these, intensity modulation of the semiconductor laser was carried out, optical transmission of the modulating-signal light was carried out, and research and development in the method (henceforth a package FM-TV transmission system) to which bundles up by the receiving side and it restores to a multi-channel video signal was done. Since a package FM-TV transmission system has large noise proof stress, it can take a transmission distance and an optical large degree in an optical transmission system with the large level difference between transmission and reception. And although the signal by which optical transmission is carried out is a broadband, since channel selection can be carried out with the general-purpose tuner for cable television from the signal to which could restore in the easy circuit and it restored by using a high speed IC, a receiver can be constituted cheaply.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] As explained above, according to this invention,-izing of the frequency band can be carried out [broadband] compared with the former, and the lightwave signal transmission equipment using the modulation-technique conversion circuit and it which make possible a quality signal transmission with few noises can be obtained.
[0065] An optical frequency modulation means to input an electrical signal and to output in more detail the signal light which carried out the optical frequency modulation according to invention according to claim 1 to 3, The optical-heterodyne-detection section which outputs the modulating signal which inputted signal light and carried out frequency conversion to the intermediate frequency, Since it has an unnecessary on-the-strength component clearance means to remove AM component in the signal which generates an optical frequency modulation means generated in said optical frequency modulation means AM component intermingled in optical frequency modulating-signal light can be removed, and an intermediate frequency can be made into type FM modulated wave symmetrical as a core for the spectrum of FM modulation component. Moreover, the noise on the strength made from the amplitude fluctuation of optical frequency modulating-signal light or local oscillation light is removable. Moreover, the frequency fluctuation of FM modulation component produced from fluctuation of optical frequency modulating-signal light is removable. Moreover, although the optical transmission device by this invention is especially used for transmission of a multi-channel video signal and is effective, it may be used also for transmission of other signals and can make possible a quality signal transmission with few distortion and noises.
[0066] Moreover, according to invention according to claim 4 to 6, the lightwave signal transmission equipment which can acquire the same effectiveness as it is obtained by invention according to claim 1 to 3 can be offered.
[0067]
[0068]
[0069]
[0070]
[0071]

[Translation done.]

* NOTICES *

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, since the modulator which carries out the frequency modulation of the multi-channel video signal collectively is conventionally constituted using the voltage controlled oscillator (it is hereafter described as VCO), a limit is in the frequency band which can be modulated by the band limit of the input frequency of VCO. Since the input impedance of VCO generally becomes large in a RF, about 200MHz of the electrical signal which can be inputted into VCO is a limitation. Since it is restricted by the frequency (for example, 90MHz) of a radio broadcasting, the minimum of a frequency band usable to transmission of television broadcasting serves as a frequency band which can be used for transmission of an about 90-200MHz band of television broadcasting, when using VCO. For example, if transmission band width of face required for transmission per channel of television broadcasting is set to 6MHz, in using VCO, the number of the image channels which can be transmitted simultaneously will become about 20 channels. Furthermore, producing VCO which crosses to a large frequency band and maintains linearity also has a problem on production of being difficult.
[0006] This invention was made under such a background, can carry out [broadband]-izing of the frequency band compared with the former, and aims at offering the lightwave signal transmission equipment using the modulation-technique conversion circuit and it which make possible a quality signal transmission with few distortion and noises.

[Translation done.]

MEANS

[Means for Solving the Problem] In order to solve the above-mentioned technical problem, invention according to claim 1 An optical frequency modulation means to input an electrical signal and to output the signal light which carried out the optical frequency modulation, An optical frequency oscillation means to output said signal light and the local oscillation light of optical frequency which left only the predetermined intermediate frequency, It has an optical multiplexing means to multiplex said signal light and said local oscillation light, and a photo-electric-translation means to change and output the output of said optical multiplexing means to an electrical signal. The optical-heterodyne-detection section which outputs the modulating signal which inputted said signal light and carried out frequency conversion to said intermediate frequency, It has an unnecessary on-the-strength component clearance means to remove AM component in the signal which generates an optical frequency modulation means generated in said optical frequency modulation means. Said unnecessary on-the-strength component clearance means It is the modulation-technique conversion circuit characterized by consisting of a distribution means to distribute the electrical signal inputted into said optical frequency modulation means, and a multiplexing means to multiplex one of the outputs of said distribution means due to the output modulating signal of said optical-heterodyne-detection section, and an opposite phase.
[0008] Moreover, an optical frequency modulation means to output the signal light which invention according to claim 2 inputted the electrical signal, and carried out the optical frequency modulation, An optical frequency oscillation means to output said signal light and the local oscillation light of optical frequency which left only the predetermined intermediate frequency, It has an optical multiplexing means to multiplex said signal light and said local oscillation light, and a photo-electric-translation means to change and output the output of said optical multiplexing means to an electrical signal. The optical-heterodyne-detection section which outputs the modulating signal which inputted said signal light and carried out frequency conversion to said intermediate frequency, It has an unnecessary on-the-strength component clearance means to remove AM component in the signal which generates an optical frequency modulation means generated in said optical frequency modulation means. Said unnecessary on-the-strength component clearance means It is the modulation-technique conversion circuit characterized by consisting of a distribution means to distribute the electrical signal inputted into said optical frequency modulation means, and an optical intensity modulation means which carries out intensity modulation of the output signal light of said optical frequency modulation means with one output of said distribution means.
[0009] Moreover, an optical frequency modulation means to output the signal light which invention according to claim 3 inputted the electrical signal, and carried out the optical frequency modulation, An optical frequency oscillation means to output said signal light and the local oscillation light of optical frequency which left only the predetermined intermediate frequency, It has an optical multiplexing means to multiplex said signal light and said local oscillation light, and a photo-electric-translation means to change and output the output of said optical multiplexing means to an electrical signal. The optical-heterodyne-detection section which outputs the modulating signal which inputted said signal light and carried out frequency conversion to said intermediate frequency, It has an unnecessary on-the-strength component clearance means to remove AM component in the signal which generates an optical frequency modulation means generated in said optical frequency modulation means. Said unnecessary on-the-strength component clearance means Optical intensity modulation of one side of the output of a dichotomy means to dichotomize the output signal light of said optical frequency modulation means, and said dichotomy means is carried out. An optical intensity modulation means to supply the output which carried out optical intensity modulation to said optical-heterodyne-detection section, Another output of said dichotomy means is changed into an electrical signal, and it is the modulation-technique conversion circuit

characterized by consisting of an optical/electrical converter for inputting the changed electrical signal into said optical intensity modulation means as a modulating signal by the opposite phase.
[0010] Moreover, an optical frequency modulation means to output the signal light which invention according to claim 4 inputted the electrical signal, and carried out the optical frequency modulation, An optical frequency oscillation means to output said signal light and the local oscillation light of optical frequency which left only the predetermined intermediate frequency, It has an optical multiplexing means to compound said signal light and said local oscillation light, and the 1st photo-electric-translation means which changes and outputs the output of said optical multiplexing means to an electrical signal. The modulation-technique conversion circuit which consists of the optical-heterodyne-detection section which outputs the modulating signal which inputted said signal light and carried out frequency conversion to said intermediate frequency, The optical sending set which consists of a transmitting means to output the transmitting light which carried out intensity modulation with the output of said modulation-technique conversion circuit, In the lightwave signal transmission equipment which is connected to an optical transmission line and said optical sending set through said optical transmission line, and is equipped with the optical receiving set which consists of the 2nd photo-electric-translation means and a frequency recovery means which carries out the frequency recovery of the output of said 2nd photo-electric-translation means It has an unnecessary on-the-strength component clearance means to remove AM component in the signal which generates an optical frequency modulation means generated in said optical frequency modulation means. Said unnecessary on-the-strength component clearance means It is the lightwave signal transmission equipment characterized by consisting of a distribution means to distribute the electrical signal inputted into said optical frequency modulation means, and a multiplexing means to multiplex one of the outputs of said distribution means due to the output modulating signal of said optical-heterodyne-detection section, and an opposite phase. [0011] Moreover, an optical frequency modulation means to output the signal light which invention according to claim 5 inputted the electrical signal, and carried out the optical frequency modulation, An optical frequency oscillation means to output said signal light and the local oscillation light of optical frequency which left only the predetermined intermediate frequency, It has an optical multiplexing means to compound said signal light and said local oscillation light, and the 1st photo-electric-translation means which changes and outputs the output of said optical multiplexing means to an electrical signal. The modulation-technique conversion circuit which consists of the optical-heterodyne-detection section which outputs the modulating signal which inputted said signal light and carried out frequency conversion to said intermediate frequency, The optical sending set which consists of a transmitting means to output the transmitting light which carried out intensity modulation with the output of said modulation-technique conversion circuit, In the lightwave signal transmission equipment which is connected to an optical transmission line and said optical sending set through said optical transmission line, and is equipped with the optical receiving set which consists of the 2nd photo-electric-translation means and a frequency recovery means which carries out the frequency recovery of the output of said 2nd photo-electric-translation means It has an unnecessary on-the-strength component clearance means to remove AM component in the signal which generates an optical frequency modulation means generated in said optical frequency modulation means. Said unnecessary on-the-strength component clearance means It is the lightwave signal transmission equipment characterized by consisting of a distribution means to distribute the electrical signal inputted into said optical frequency modulation means, and an optical intensity modulation means which carries out intensity modulation of the output signal light of said optical frequency modulation means with one output of said distribution means.
[0012] Moreover, an optical frequency modulation means to output the signal light which invention according to claim 6 inputted the electrical signal, and carried out the optical frequency modulation, An optical frequency oscillation means to output said signal light and the local oscillation light of optical frequency which left only the predetermined intermediate frequency, It has an optical multiplexing means to compound said signal light and said local oscillation light, and the 1st photo-electric-translation means which changes and outputs the output of said optical multiplexing means to an electrical signal. The modulation-technique conversion circuit which consists of the optical-heterodyne-detection section which outputs the modulating signal which inputted said signal light and carried out frequency conversion to said intermediate frequency, The optical sending set which consists of a transmitting means to output the transmitting light which carried out intensity modulation with the output of said modulation-technique conversion circuit, In the lightwave signal transmission equipment which is connected to an optical transmission line and said optical sending set through said optical transmission line, and is equipped with the optical receiving set which consists of the 2nd photo-electric-translation means and a frequency recovery means which carries out the frequency recovery of the output of said 2nd photo-electric-

translation means It has an unnecessary on-the-strength component clearance means to remove AM component in the signal which generates an optical frequency modulation means generated in said optical frequency modulation means. Said unnecessary on-the-strength component clearance means Optical intensity modulation of one side of the output of a dichotomy means to dichotomize the output signal light of said optical frequency modulation means, and said dichotomy means is carried out. An optical intensity modulation means to supply the output which carried out optical intensity modulation to said optical-heterodyne-detection section, Another output of said dichotomy means is changed into an electrical signal, and it is the lightwave signal transmission equipment characterized by consisting of an optical/electrical converter for inputting the changed electrical signal into said optical intensity modulation means as a modulating signal by the opposite phase. [0013]

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[0024]
[Embodiment of the Invention] As the example of 1 configuration is shown in drawing 1 (a) - drawing 1 (c), the lightwave signal transmission equipment with which this invention is applied extracts optical FM modulation component of the semi-conductor FM laser modulated with the broadband AM input signal as an electric FM modulation component by optical heterodyne detection, carries out intensity modulation of the light source for transmission, and transmits it to an optical transmission line. Drawing 1 (a) is the block diagram showing the whole lightwave signal transmission equipment 100 configuration. The lightwave signal transmission equipment 100 consists of SLT (subscriber line terminal)1, an optical transmission line 2, ONU (optical network termination) 3, and a television set 4. However, the television set 4 which receives AM video signal outputted from ONU3 can be transposed to devices, such as a video tape recorder which has a receive section. Furthermore, the configuration which does not contain a television set 4 can also be considered as one mode of the lightwave signal transmission equipment by this invention. In addition, the outline of such lightwave signal transmission equipment "Optical Super by the artificer of this application Wide-Band FM Modulation Scheme and Its Application to Multi-Channel AM Video Transmission Systems", International Conference on Integrated Optics It is indicated by and Optical FIbre Communication, IOOC-95, June 26-30, 1995, Technical Digest, and volume 5-Postdeadline Papers.
[0025] SLT1 shown in drawing 1 (a) consists of an AM/FM (amplitude modulation/frequency modulation) converter 11 and DFB (distribution feedback) laser 12. SLT1 inputs and transmits collectively AM video signal of the many channels by which frequency division multiplex was carried out to up to an optical transmission line 2 as an optical transmission signal by which intensity modulation was carried out with the multi-channel video signal changed and changed into FM video signal. An optical transmission line 2 transmits a lightwave signal using two or more optical fibers 22 connected to the branching output of an optical fiber 20, the optical star coupler 21, and the optical star coupler 21 with the passive double star (PDS) method which enables the communication link of one-pair a large number. ONU3 receives and carries out photo electric translation of the optical transmission signal transmitted through an optical transmission line 2 by photo electric translation and the FM/AM converter 30, and restores to it and outputs it to AM video signal. A television set 4 receives AM video signal outputted from ONU3, and projects the image of the channel of the arbitration chosen by the user from multiple channels.
[0026] Drawing 1 (b) is the block diagram showing the internal configuration of the AM/FM converter 11 shown in drawing 1 (a). The AM/FM converter 11 consists of the optical frequency modulation section 111 and the optical-heterodyne-detection section 112. The optical frequency modulation section 111 contains the semi-conductor FM laser 111-1. The optical-heterodyne-detection section 112 is equipped with the optical/electrical converter 112-3 which consists of the optical frequency local oscillator 112-1 and the optical multiplexing machine 112-2 which consist of semi-conductor local laser 112-10, and PD (photodiode). On the other hand,

photo electric translation and the FM/AM converter 30 consist of an optical/electrical converter 31 which consists of APD (ABARANSHU photodiode) as shown in drawing 1 (c), and the FM recovery section 32. FM recovery section 32 restores to FM electrical signal transformed into the electrical signal with the optical/electrical converter 31 to AM electrical signal by differentially coherent detection using the reversal non-inversed amplifier 32-1, the delay line 32-2, an exclusive "or" circuit 32-3, and a low pass filter 32-4.
[0027] The lightwave signal transmission equipment shown in drawing 1 by the above configuration inputs into SLT1 AM video signal of the many channels by which frequency division multiplex was carried out, and carries out FM modulation of the semi-conductor FM laser 111-1 with this input signal. Using the optical frequency local oscillator 112-1 and the optical multiplexing machine 112-2, with an optical-heterodyne-detection technique, the optical-heterodyne-detection section 112 obtains an optical frequency modulation component from the output of the semi-conductor FM laser 111-1 modulated with the broadband AM input signal, it carries out photo electric translation with an optical/electrical converter 112-3 further, and it extracts an electric package FM modulation component. Intensity modulation of the light source for transmission using DFB laser 12 is carried out by the electric package FM modulation component outputted from an optical/electrical converter 112-3, and the lightwave signal by which intensity modulation was carried out is transmitted to an optical transmission line 2. On the other hand, in a receiving side, photo electric translation of the optical transmission signal transmitted through an optical transmission line 2 is received and carried out with an optical/electrical converter 31 in ONU3. And in FM recovery section 32, it gets over to AM video signal by differentially coherent detection.
[0028] The spectrum of the recovery multi-channel AM video signal to which bundles up an example of the spectrum of the electric package FM modulation component obtained by drawing 2 (a) as an output of the optical-heterodyne-detection section 112 by FM recovery section 32 to drawing 2 (b), and it restores is shown. Drawing 2 (a) shows the center frequency of the spectrum of an electric package FM modulation component, and the intermediate frequency shows the case of 1.75GHz. Drawing 2 (b) shows the case where it restores to AM video signal of 40 channels.
[0029] When applying the lightwave signal transmission equipment of a configuration of being shown in drawing 1 (a) -1(c) to a cable television system, it becomes possible to put in block AM video signal of dozens of channels, to change into one FM signal, to send this out to an optical transmission line, to put this FM transmission signal in block by differentially coherent detection etc. by the receiving side, and to get over to a multi-channel AM video signal. That is, according to the above configuration, with the package FM-TV transmission system which used VCO conventionally, the signal transmission of the difficult wide band of realizing becomes possible. However, in order in using lightwave signal transmission equipment mentioned above to decrease a noise and to make a quality signal transmission possible, to adopt each configuration by this invention explained further below in addition to the above configuration is desired.
[0030] In the package FM-TV transmission system with which the configuration shown in drawing 1 (a) and drawing 1 (c) is included, it turns out that the value of CNR (Carrier to Noise Ratio: carrier-to-noise ratio) obtained when it restores to the output signal in the photo electric translation in ONU3 and the output terminal (namely, output terminal of FM recovery section 32) of the FM/AM converter 30 to AM video signal is dependent on the number of channels to transmit. That is, CNR can be improved by reducing the number of channels. However, when the number of channels is reduced for the purpose of the improvement of CNR, the operation effectiveness of the signal transmission of the wide band obtained by the above-mentioned configuration is no longer employed fully efficiently. Therefore, a technique which can perform the improvement of CNR was desired, without reducing the number of channels. On the other hand, this invention sets it as the detailed object to offer the modulation-technique conversion circuit which can improve CNR, and lightwave signal transmission equipment, without reducing the number of channels, and offers the configuration for it.
[0031] the ratio of the power PFM of the signal light (FM laser beam) inputted into an optical/electrical converter 112-3 in the optical-heterodyne-detection section 112 which shows drawing 3 (a) and drawing 3 (b) to drawing 1 (b), and the power PLO of the local oscillation light (local laser beam) outputted from the optical frequency local oscillator 112-1 -- the relation of PFM/PLO and CNR when restoring to a modulating signal to AM video signal in the output terminal of the AM/FM converter 11 is shown. Here, drawing 3 (a) shows measured value in case it is 2.75GHz, the center frequency, i.e., the intermediate frequency, of FM signal spectrum, and, as for drawing 3 (b), shows the measured value in 3.85GHz. Both are the transmission characteristics of 20 channels. Moreover, frequency deviation deltaf per channel is 220MHz0-p/ch and 280MHz0-p/ch, respectively, when intermediate frequencies are 2.75GHz and 3.85GHz.
[0032] As shown in these drawings, CNR of AM video signal changes depending on the value of the ratios

PFM/PLO of the power PFM of FM laser beam, and the power PLO of a local laser beam. Furthermore, the relation between CNR and the power ratios PFM/PLO changes with the magnitude of an intermediate frequency. Moreover, as for CNR serving as max, drawing 3 (a) and drawing 3 (b) show that an optical power ratio is about 0dB. therefore, the ratio of Power PFM and Power PLO -- it becomes possible by controlling PFM/PLO in the range of desired to obtain desired CNR.

[0033] By the way, the specification of the transmission quality in the same axle CATV about current and CNR is 42dB or more. Moreover, if in charge of controlling the power ratios PFM/PLO actually, it is necessary to expect about **4dB of initial manufacture deflection to a design value about the power PFM of FM laser beam, and each power PLO of a local laser beam. Therefore, if it thinks in consideration of these conditions based on the property shown in drawing 3 (a) and drawing 3 (b), in order to acquire the property of CNR which is the stable quality and satisfies 42dB or more of specification of the transmission quality, it is desirable to control the ratio of PFM/PLO to -8<PFM/PLO<8[dB].

[0034] Next, other operation gestalten by this invention of the AM/FM converter 11 of the lightwave signal transmission equipment shown in drawing 1 (a) and drawing 1 (b) are explained to the drawing 2 (a) list with reference to drawing 4 - drawing 8. In the optical frequency modulation section 111 shown in drawing 1 (b) mentioned above, the optical frequency modulation is applied to FM laser beam outputted by changing the inrush current of the FM laser 111-1 constituted by semiconductor laser according to an input signal. However, in an optical heterodyne output, since optical intensity modulation also starts FM laser beam by change of an inrush current in this case, as shown in the electric package FM modulating-signal spectrum of drawing 2 (a), an AM component will be simultaneously intermingled not only in FM component. On the other hand, it is ideal FM modulation that the spectrum becomes a symmetry form focusing on an intermediate frequency (the example of drawing 2 (a) 1.75GHz) about FM modulation component. However, since not only frequency modulation but intensity modulation starts FM laser beam simultaneously actually, a spectrum becomes unsymmetrical. Moreover, there is fluctuation in the amplitude of FM laser beam or a local laser beam, and since these will become distortion and a noise if it gets over by FM recovery section 32, they have a possibility of becoming the cause by which image quality makes it deteriorate. Moreover, since fluctuation of the optical frequency of FM laser beam and fluctuation of the optical frequency of a local laser beam will also become a noise too if it gets over by FM recovery section 32, they have a possibility of becoming the cause by which image quality deteriorates. Then, the operation gestalt by this invention shown below aims at the cure, and makes possible a quality signal transmission with still few distortion and noises.

[0035] Drawing 4 shows other operation gestalten by this invention of AM / FM converter 11 shown in drawing 1 (a). The same sign is attached to the same thing as the configuration shown in drawing 1 (a) or drawing 1 (b) in drawing 4. In addition, in other operation gestalten shown below, the same sign is similarly attached to the same configuration. AM/FM converter 11B shown in this drawing Differential distributor 11B-1 which 180 degrees of phases of an input AM video signal are changed, and distributes them, Amplitude regulator 11B-2 which input one electrical signal between two outputs of differential distributor 11B-1, and adjust the amplitude, It newly has inphase composition machine 11B-4 which are in phase and compound time delay regulator 11B-3 which give delay to the output electrical signal of amplitude regulator 11B-2, the output electrical signal of time delay regulator 11B-3, and the electric package FM modulation component based on the output of another side of differential distributor 11B-1. In AM/FM converter 11B, differential distributor 11B-1 distributes a phase for AM video signal due to an opposite phase (0 degree and 180 degrees), one output (phase; 0 degree) is inputted into the FM laser 111-1, and the output is supplied to the optical-heterodyne-detection section 112. The optical-heterodyne-detection section 112 carries out optical heterodyne detection of the inputted lightwave signal, further, by PD 112-3, is changed into an electrical signal and outputs a frequency modulation signal. Inphase composition of the electrical signal outputted from PD 112-3 and the electrical signal based on another output (phase; 180 degrees) of differential distributor 11B-1 is carried out by inphase composition machine 11B-4. At this time, amplitude adjustment is carried out by amplitude regulator 11B-2, and time delay adjustment of the electrical signal inputted into inphase composition machine 11B-4 from phase the side of 180 degrees is further carried out by time delay regulator 11B-3 so that the AM component of optical frequency modulating-signal light and the amplitude of tales doses may make an opposite phase. Therefore, each input signal of inphase composition machine 11B-4 offsets each AM component in inphase composition machine 11B-4. The spectrum of the output of PD 112-3 was shown in (1), and the spectrum of the output of time delay regulator 11B-3 was shown in (2) among drawing. In addition, although the configuration which distributes an opposite phase component and performs inphase composition was shown, it can be in phase, can distribute and can also change

into the configuration which performs differential composition here. This modification is possible similarly in the operation gestalt shown in drawing 7 described later or drawing 11.
[0036] the ratio of the power PFM of signal light (FM laser beam) and the power PLO of a local laser beam which are inputted into the optical/electrical converter 112-3 in AM/FM converter 11B shown in drawing 4 with reference to drawing 5 (a) and drawing 5 (b) here -- with PFM/PLO When it restores to an electric package conversion FM signal in the output terminal of inphase composition machine 11B-4 The relation between the secondary compound distortion of a ** AM video signal (CSO:Composite Second-Order Distortion) and 3rd compound distortion (CTB:Composite Triple Beat Distortion) is explained.
[0037] As for measured value in case it is 2.75GHz, the center frequency, i.e., the intermediate frequency, of FM signal spectrum, and drawing 5 (b), drawing 5 (a) shows the measured value in 3.85GHz, respectively. And both of the drawings show the transmission characteristic of 20 channels. In drawing 5 (a) and 5 (b), the property shown as a continuous line is the property of the AM/FM converter 11 shown in drawing 1 (b), and the property shown with a broken line is the property of AM/FM converter 11B shown in drawing 4. In addition, frequency deviation deltaf per channel is 220MHz0-p/ch and 280MHz0-p/ch, respectively, when intermediate frequencies are 2.75GHz and 3.85GHz. Thus, according to the configuration shown in drawing 4, by the case where it is shown in drawing 5 (a), CSO can be improved by removing AM component, not changing the value of PFM/PLO, as an arrow head shows. Moreover, in the case of drawing 5 (b), both CSO and CTB can be improved, not changing the value of PFM/PLO, as an arrow head shows. Therefore, it is possible to improve both CNR and distortion (CSO, CTB) by applying AM component clearance and the control of the predetermined range of an optical power ratio mentioned above.
[0038] Drawing 6 is the block diagram showing other configurations of the operation gestalt for carrying out AM component clearance like AM/FM converter 11B explained with reference to drawing 4. Optical-heterodyne-detection section 112C consists of AM/FM converter 11C shown in drawing 6 using optical/electrical converter 112C-3 considered as the balance DORESHIBA configuration. In optical-heterodyne-detection section 112C, optical/electrical converter 112C-3 consist of two PDs which corresponded, and the optical path length from the optical multiplexing machine 112-2 to two PDs is in agreement. In this case, in optical/electrical converter 112C-3, the amount of on-the-strength strange preparation is in phase, it is received, and a frequency modulation component is received by the opposite phase. Since optical/electrical converter 112C-3 are constituted so that each polarity of two PDs may become reverse mutually, a part for on-the-strength strange preparation is offset, and a frequency modulation component is added there.
[0039] In this case, one of the features of considering as a balance DORESHIBA configuration is the point which can also offset a part for a part for the on-the-strength strange preparation of FM laser beam, and the on-the-strength strange preparation of not only fluctuation on the strength but a local laser beam, and fluctuation on the strength. Another features are that it uses both of the outputs of the optical multiplexing machine 112-2 which consists of a directional coupler. Since according to this a frequency modulation component is added as mentioned above, optical power can be used effectively. In addition, balance DORESHIBA is explained to the following reference Kiyoshi Nosu, Katsushi Iwashita, and Nori Shibata, Masao Kawachi, Hiromu Toba, Osamu Ishida, Takeshi Ito, and Kyo Inoue, "Coherenct Lightwave Communications Technology", pp.76-79, Chapman & Hall, London, and 1995 in detail, for example.
[0040] When the configuration of drawing 4 is compared with the configuration of drawing 6, the configuration of drawing 4 has the advantage of being cheap, compared with the configuration of drawing 6 which used balance DORESHIBA. All of differential distributor 11B-1 used, amplitude regulator 11B-2, and time delay regulator 11B-3 should just operate below the more than frequency of a multi-channel video signal, for example, 0MHz, and 350MHz, and it is because the electronic parts used are cheap. Although it is inphase composition machine 11B-4 used as high frequency (frequency of a package FM signal), it is cheap too that is not uniquely cheap, if compared with balance DORESHIBA. On the other hand, since the optical/electrical converters (PD) which operate by the RF are 2 need, balance DORESHIBA becomes expensive as compared with the configuration shown in drawing 4. In the conventional lightwave signal transmission system, across the long optical transmission line, the optical transmitting section (configuration corresponding to SLT1 shown in drawing 1 (a)) and an optical receive section (configuration corresponding to ONU3 shown in drawing 1 (a)) separate, and are usually established. It is desirable to perform optical heterodyne detection with such a configuration only using the lightwave signal which has passed through the long optical transmission line in an optical receive section. In such a configuration, balance DORESHIBA is used in order to acquire a quality recovery signal.
[0041] On the other hand, AM component clearance of the configuration of drawing 4 is carried out using the

output of an optical/electrical converter 112-3, and the electrical signal based on the modulating signal of the FM laser 111-1. When it is going to adopt this configuration, in the conventional configuration, it will be necessary to lay the signal-transmission way for AM components independently, or to install new equipment in a receive section. Since each components 112-10,112-2,112-3 of all that constitute the FM laser 111-1 and the optical-heterodyne-detection section 112 from a configuration of AM/FM converter 11B shown in drawing 4 by this invention are installed in SLT1 of a transmitting side and it is in point-blank range, it is possible to compound the electrical signal and the output electrical signal of the optical-heterodyne-detection section 112 which distributed the input to the FM laser 111-1 with a simple configuration. Therefore, it is possible to employ efficiently the advantage of being cheaper than the configuration using difficult balance DORESHIBA, with the conventional configuration.
[0042] On the other hand, the advantage of the configuration using balance DORESHIBA shown in drawing 6 is the point that the component on the strength which can be offset can contain not only the thing of FM laser but the thing of local laser. However, since the distance between the FM laser 111-1 and PD 112-3 can make low local oscillation light power (output of the local laser 112-2) also in a configuration like drawing 4 about this point when it be comparatively short, it be expectable by make small effect of fluctuation on the strength of a local laser beam to acquire the same property as the case where balance DORESHIBA be use.
[0043] Next, other modifications of AM/FM converter 11B shown in drawing 4 with reference to drawing 7 are explained. In addition to each configuration of differential distributor 11B-1 with which AM/FM converter 11B shown in drawing 4 is equipped, amplitude regulator 11B-2, time delay regulator 11B-3, and the optical-heterodyne-detection section 112, AM/FM converter 11D shown in drawing 7 has optical intensity modulator 11C-6 which newly carry out optical intensity modulation of the FM laser beam with the output of time delay regulator 11B-3. With this operation gestalt, the input of the FM laser 111-1 is dichotomized at 0 degree and 180 degrees by actuation distributor 11B-1, intensity modulation of the lightwave signal by the side of 0 degree is carried out using the signal by the side of 180 degrees, and an AM component is offset.
[0044] Drawing 8 is the block diagram showing other modifications of AM/FM converter 11B shown in drawing 4. In AM/FM converter 11E shown in drawing 8 The output of the FM laser 111-1 The output of amplitude controller 11C-3 which adjust the amplitude and time delay of PD11C-2 which change one dichotomous output light of optical turnout 11C-1 and optical turnout 11C-1 into an electrical signal, and the output electrical signal of those and time delay regulator 11C-4, and time delay regulator 11C-4 Phase-inverter 11C-5 to reverse and optical intensity modulator 11C-6 which carry out optical intensity modulation of another output light of optical turnout 11C-1 with the output of phase-inverter 11C-5 are newly prepared. And in AM/FM converter 11E, the output light of optical intensity modulator 11C-6 was detected in the optical-heterodyne-detection section 112, and the electric package FM modulation component has been obtained.
[0045] In AM/FM converter 11E shown in drawing 8 The optical frequency modulating-signal light modulated by the input AM video signal in the FM laser 111-1 is dichotomized by optical turnout 11C-1. By inputting into optical intensity modulator 11C-6 by the opposite phase eventually, and carrying out intensity modulation of other output light of optical turnout 11C-1, after inputting one side into optical intensity modulator 11C-6 and changing another side into an electrical signal by PD11C-2 The AM component of the output light of optical intensity modulator 11C-6 is offset. In this case, in amplitude regulator 11C-3 and time delay regulator 11C-4, the amplitude and phase of the electrical signal inputted into optical intensity modulator 11C-6 are adjusted so that an AM component may be offset and the spectrum of FM modulation component may serve as a symmetry form as much as possible focusing on an intermediate frequency. With the operation gestalt shown in drawing 7 and drawing 8, an AM component is offset in the state of the lightwave signal which was sent out from the FM laser 111-1 with the output which carried out photo electric translation using PD like the operation gestalt shown in the configuration using balance DORESHIBA shown in drawing 6, or drawing 4 unlike having offset the AM component. In a configuration of having been shown in the configuration using balance DORESHIBA or drawing 4, the AM component or the fluctuation on the strength which are included in an intermediate frequency cannot be offset. On the other hand, with the configuration of drawing 7 and drawing 8, since the AM component is offset in the phase of light, the fluctuation on the strength of an AM component or FM laser can be offset covering all the frequencies of the output of PD. It corrects, Since the configuration of drawing 7 and drawing 8 cannot set off the local oscillation luminous-intensity fluctuation of the local laser 112-10 against there being an inclination which becomes expensive since components mark increase, about this point, it can be said that the direction of the operation gestalt shown in drawing 6 is excellent.
[0046] In addition, with the operation gestalt shown in drawing 8, although phase-inverter 11C-5 are used, since

it can be made reversed with the polarity of PD11C-2, when it is made such, phase-inverter 11C-5 can be omitted. This is the same also with the operation gestalt shown in drawing 13 described later.

[0047] Drawing 9 and drawing 10 are the block diagrams showing other operation gestalten of the lightwave signal transmission equipment by this invention. With the operation gestalt shown in drawing 9 and drawing 10, after superimposing a pilot signal on a broadband AM input signal, semi-conductor FM laser is modulated. And two band pass filter 11E-1 and 11E-2 extract FM modulating signal and the pilot signal which were acquired by optical heterodyne detection, and they carry out frequency-mixing by frequency mixer 11E-3 further. According to the operation gestalt, the noise resulting from the fluctuation component of the frequency of semi-conductor FM laser and the frequency fluctuation component of the laser for local oscillation is removable with this. As compared with the lightwave signal transmission equipment 100 shown in the lightwave signal transmission equipment 101 shown in drawing 9 at drawing 1, the multiplexing machine 5 which carries out frequency multiplex [of the pilot signal with which frequencies differ in AM video signal] is newly formed. The output of this multiplexing machine 5 is inputted into SLT1F. In addition, about offset of the fluctuation component by using a pilot signal, it is advocated with the following reference [reference:Y.H.Cheng, T.Okoshi, "Phase-noise-cancelling dual-frequency heterodyne optical fibre communication system", Electronics Letter, vol.25, no.13, pp.835-836, and 1989.].

[0048] Here, the detail of actuation of AM/FM converter 11K is explained using drawing 14. Drawing 14 shows the spectrum in (G) from each part (A) in each operation gestalt shown in drawing 10 and drawing 11 mentioned later, drawing 12, and drawing 13. In drawing 9, the multiplexing machine 5 carries out frequency multiplex [of the pilot signal] to AM video signal. Here, it is assumed that it is that from which the electrical signal with which frequency multiplex [of AM video signal with a frequency of 90MHz - 450MHz and the frequency fp=2.1GHz pilot signal] was carried out is acquired as an output (A) of the multiplexing machine 5 as an example ((A) of drawing 14). The optical frequency modulation section 111 shown in drawing 10 outputs the optical frequency modulating signal which carries out optical FM modulation of the FM laser 111-1 according to the inrush current according to the electrical signal (A) inputted from the multiplexing machine 5, for example, sets center frequency f1 to 193,006.1 GHz ((B) of drawing 14). In the output (B) of the optical frequency modulation section 111, the frequency component which fluctuation **f1 by the FM laser 111-1 generated to the intermediate frequency f1 of FM modulating signal, and the lightwave signal containing frequency component f1**fp (193,004. 0 GHz and 193,008.2 GHz) of a pilot signal which has fluctuation **f1 similarly again appear.

[0049] It uses the local oscillation light (C) from the optical frequency local oscillator 112-1 shown in (C) of drawing 14, and the optical-heterodyne-detection section 112 (may be local oscillation optical frequency f2=193,000GHz here) by considering optical frequency modulating-signal light (B) from the optical frequency modulation section 111 as an input, and the electrical signal which detected by performing optical heterodyne detection is outputted from an optical/electrical converter 112-3. (D) of drawing 14 shows the spectrum of electric FM package modulation component (D) outputted from an optical/electrical converter 112-3. Since the output of the optical frequency local oscillator 112-1 is the local oscillation light of the local laser 112-10 and the oscillation frequency f2 has become what swung by fluctuation component **f2 Electric FM package modulation component (D) becomes what swung by fluctuation **f (=**f1+**f2) further from the main oscillation frequency f1 of the FM laser 111-1 about the center frequency as f1-f2 which subtracted the local oscillation frequency f2. Moreover, electric FM package modulation component (D) contains the frequency component of f1-f2**fp by the pilot signal simultaneously. In this case, electric FM package modulation component (D) serves as a signal containing each frequency component (center frequency f1-f2=6.1GHz, f1-f2**fp=8.2GHz by the pilot signal, and 4.0GHz).

[0050] The fluctuation of the optical frequency of optical frequency modulating-signal light (B) and local oscillation light (C) is changed into fluctuation of an electrical signal (D) as it is. Moreover, fluctuation of the electric frequency of a package FM modulation component and the fluctuation of the electric frequency of a pilot signal become identitas (**f=**f1+**f2). The results of having taken out the package FM modulation component (D) and a round wave number component of a pilot signal using band pass filter 11E-1 and 11E-2, respectively are (E) of drawing 14, and (F). If frequency-mixing of these is carried out by frequency mixer 11E-3, the electrical signal (G) which makes center frequency against which the fluctuation component was set off the frequency fp of a pilot signal can be taken out from frequency mixer 11E-3 ((G) of drawing 14).

[0051] Drawing 11 is the block diagram showing another configuration of AM/FM converter 11K in SLT1F shown in drawing 9. In AM/FM converter 11F, the signal which superimposed the pilot signal on AM image input signal by differential distributor 11B-1 Distribute a phase due to an opposite phase (0 degree and 180 degrees), and

the output (phase; 0 degree) of one of these is inputted into the optical frequency modulation section 111. Inphase composition of another [the electrical signal outputted from the optical-heterodyne-detection section 112 and] output (phase; 180 degrees) of differential distributor 11B-1 is carried out by inphase composition machine 11B-4. The output by which inphase composition was carried out dichotomizes and is divided into FM signal modulation component and a pilot signal by two band pass filter 11E-1 and 11E-2, respectively. Frequency-mixing of these [which were separated] two electrical signals is carried out by the multiplier in E-frequency mixer 113. As mentioned above, fluctuation of the optical frequency of optical frequency modulating-signal light and local oscillation light is offset by performing frequency-mixing. According to AM/FM converter 11F shown in drawing 11, the clearance effectiveness of the fluctuation component by using a pilot signal and the effectiveness of offset of the same AM component as the operation gestalt shown in drawing 4 can be doubled and acquired.

[0052] Drawing 12 is drawing showing other operation gestalten of AM/FM converter 11K shown in drawing 9. AM/FM converter 11G shown in drawing 12 are equipped with the optical frequency modulation section 111 and optical-heterodyne-detection section 112C which are constituted like AM/FM converter 11C shown in drawing 6, and prepare frequency mixer 11E-3 which mix band pass filter 11E-2 and those outputs for extracting band pass filter 11E-1 and the pilot signal for newly extracting FM modulating-signal component. In AM/FM converter 11G, the FM laser 111-1 is modulated with the electrical signal which superimposed the pilot signal on AM image input signal. And by balance DORESHIBA 112C-3, optical heterodyne detection of the output light of the FM laser 111-1 is carried out, it dichotomizes, the detection output is inputted into two band pass filter 11E-1 and 11E-2, and it separates into FM signal modulation component and a pilot signal. Frequency-mixing of these [which were furthermore separated] two electrical signals is carried out by frequency mixer 11E-3, and fluctuation of the optical frequency of optical frequency modulating-signal light and local oscillation light is offset. According to the operation gestalt shown in this drawing, the effectiveness which offsets the same part for the on-the-strength strange preparation of FM laser beam and fluctuation on the strength as the clearance effectiveness of the fluctuation component by using a pilot signal and the operation gestalt shown in drawing 6, and a part for the on-the-strength strange preparation of a local laser beam and fluctuation on the strength can be doubled and acquired.

[0053] Drawing 13 is drawing showing other operation gestalten of AM/FM converter 11K shown in drawing 9. AM/FM converter 11H shown in drawing 13 modulate the FM laser 111-1 with the electrical signal which superimposed the pilot signal on AM image input signal. It dichotomizes by optical turnout 11C-1, and one side is inputted into optical intensity modulator 11C-6, and another side is inputted into PD11C-2, and the optical frequency modulating-signal light outputted from the FM laser 111-1 is changed into an electrical signal, and is further inputted into optical intensity modulator 11C-6 by the opposite phase through amplitude regulator 11C-3, time delay regulator 11C-4, and phase-inverter 11C-5. By carrying out intensity modulation of the lightwave signal inputted into optical intensity modulator 11C-6 with the electrical signal outputted from phase-inverter 11C-5, the AM component in the output light of optical intensity modulator 11C-6 is offset. It dichotomizes, the detection output (D) which carried out optical heterodyne detection of this output light of optical intensity modulator 11C-6 is inputted into two band pass filter 11E-1 and 11E-2, and it separates into FM signal modulation component (E) and a pilot signal (F). And frequency-mixing of these [which were separated] two electrical signals is carried out by frequency mixer 11E-3, and fluctuation of the optical frequency of optical frequency modulating-signal light and local oscillation light is offset. According to the operation gestalt shown in drawing 13, the clearance effectiveness of the fluctuation component by using a pilot signal and the effectiveness which offsets the fluctuation on the strength of the same AM component as the operation gestalt shown in drawing 8 or FM laser can be doubled and acquired.

[0054] Each operation gestalt of this invention mentioned above, without being restricted to the above-mentioned gestalt in addition, for example, as other operation gestalten It changes to AM/FM converter 11K shown in drawing 9. It is possible to use the configuration which adds band pass filter 11E-1 as further shown in the output of the optical/electrical converter 112-3 of AM/FM converter 11D shown in drawing 7 drawing 11 - 13 and 11E-2, and frequency mixer 11E-3 etc.

[0055] Next, with reference to drawing 15 (a) and drawing 15 (b), other operation gestalten of the lightwave signal transmission equipment by this invention are explained. The lightwave signal transmission equipment 102 shown in drawing 15 (a) consists of the PURIDISU torsion circuit 6 established in the preceding paragraph of SLT1J, SLT1J, an optical transmission line 2, an attenuator 7, ONU3J, and a television set 4. SLT1J consist of AM/FM converter 11J, semiconductor laser 12, such as a DFB laser, and light amplifiers 13, such as erbium

dope fiber amplifier. ONU3J consist of FM recovery section 32J with the optical photo detectors 31, such as APD. In addition, AM/FM converter 11J and FM recovery section 32J are constituted like the operation gestalt explained with reference to each drawing mentioned above like the AM/FM converter 11 shown in drawing 1, and FM recovery section 32. In the lightwave signal transmission equipment 102 shown in drawing 15 (a), distortion is offset by compounding beforehand the distortion of the amount and tales doses of distortion carrying out distortion compensation in the PURIDISU torsion circuit 6 in a latter circuit by the opposite phase. The PURIDISU torsion circuit 6 can consist of FET amplifier etc. that what is necessary is just to operate by the frequency band of AM video signal, for example, 90MHz, to 280MHz rather than to operate to broadband FM signal.

[0056] Drawing 15 (b) is the block diagram showing the example of 1 configuration of the PURIDISU torsion circuit 6. The PURIDISU torsion circuit 6 shown in drawing 15 (b) consists of a turnout 61, the distortion generating circuit 62, an adjustable attenuator 63, the adjustable delay line 64, and a multiplexing machine 65. The inputted multi-channel AM video signal dichotomizes by the turnout 61, and is inputted into the distortion generating circuit 62 as the noninverting input of the multiplexing machine 65. The distortion generating circuit 62 gives a predetermined distortion to an input signal, and the adjustable attenuator 63 and the adjustable delay line 64 adjust the reinforcement and the phase of a signal further. And the signal outputted from the adjustable delay line 64 is inputted into the reversal input of the multiplexing machine 65, and it is multiplexed with another [which branched by the turnout 61] signal.

[0057] The operation acquired by the PURIDISU torsion circuit 6 mentioned above is compensating distortion produced in AM/FM converter 11J. However, by changing distortion which the PURIDISU torsion circuit 6 gives to an input signal, it can also compensate including distortion further produced in FM recovery section 32J of ONU3J, and it is also possible to include and compensate even distortion further produced by the optical-fiber-transmission way 2. In addition, as a factor of distortion produced in AM/FM converter 11J, the nonlinearity in the dynamic characteristics of the input current pair output optical frequency property of FM laser can be considered. Moreover, the group-delay deflection of the electric amplifier used in AM/FM converter 11J is considered as other factors. On the other hand, as distortion produced in FM recovery section 32J in ONU3J, the group-delay deflection of the electric amplifier which constitutes it is the factor whose number is one, and the nonlinearity of the input frequency pair output voltage property of FM recovery section 32J is also further considered as other factors. Moreover, as a factor of distortion produced by the optical-fiber-transmission way 2, distribution of the optical fiber for transmission is one factor. Therefore, what is necessary is for distortion given to an input signal in the PURIDISU torsion circuit 6 to search for these factors beforehand by count or experiment, and to change it suitably according to other factors, such as an input signal and temperature, if needed further, to set up and just to adjust it so that it may be compensated.

[0058] In addition, although this operation gestalt explained the multi-channel AM video signal as an input signal, it can explain similarly the multi-channel QAM video signal by which frequency division multiplex was carried out as an input. Moreover, the analog except a video signal or digital one can explain a broadband electrical signal similarly as an input.

[0059] In addition, although it has inputted into ONU3J with the operation gestalt shown in drawing 15 (a) after it outputs after forming the erbium dope fiber amplifier 13 in the output stage of SLT1J and amplifying the output light of DFB laser 12, and making it decrease with an attenuator 7, arrangement or the number of amplifier or an attenuator do not need to be limited to the mode of this operation gestalt. Moreover, omitting suitably is possible.

[0060] Next, other operation gestalten of the AM/FM converter by this invention are explained with reference to drawing 16 (a) and drawing 16 (b). Drawing 16 (a) and drawing 16 (b) show the block diagram of the AM/FM converter as a modification of the AM/FM converter 11 shown in drawing 1 (b), respectively. The operation gestalt shown in drawing 16 (a) and drawing 16 (b) is characterized by reducing the optical frequency fluctuation of an electric package FM signal by AFC (Auto Frequency Controller: automatic frequency control circuit)202. Optical frequency fluctuation results from fluctuation of the oscillation optical frequency of the FM laser 111-1, and fluctuation of the oscillation optical frequency of the local laser 112-10. A low pass filter 201 extracts the fluctuation component of the optical frequency of the low frequency within FM recovery signal inputted through PD204, FM recovery section 203, and AFC202. In this case, the input light of PD204 is taken out from one outgoing end of the vacant (it does not connect with PD 112-3) optical turnout 112-2. According to the fluctuation component extracted with the low pass filter 201, the negative feedback control of the optical frequency of the FM laser 111-1 (in the case of drawing 16 (a)) or the local laser 112-10 (in the case of drawing

16 (b)) is carried out. As an approach of carrying out a negative feedback control, there is a method of changing the inrush current to the FM laser 111-1 or the local laser 112-10 or a method of changing the temperature.
[0061] In addition, although this operation gestalt explained the multi-channel AM video signal as an input signal, it can explain similarly the multi-channel QAM video signal by which frequency division multiplex was carried out as an input. Moreover, . analog except a video signal or digital one can explain a broadband electrical signal similarly as an input. According to this operation gestalt shown in drawing 16 (a) and drawing 16 (b), the noise generated by optical frequency fluctuation of FM signal which carried out package conversion can be reduced.
[0062] In addition, each operation gestalt explained with reference to drawing 15 (a) and drawing 15 (b) or drawing 16 (a), and drawing 16 (b) The AM/FM converters 11L, 11M, 11N, and 11O shown in drawing 17, drawing 18, drawing 19, and drawing 20, for example, without being limited to the combination shown in those drawings, It is possible to combine with the lightwave signal transmission equipment or the AM/FM converter explained with reference to drawing 1 - drawing 14 suitably. In addition, the same sign as what was used with the above-mentioned operation gestalt is attached to each component shown in drawing 17 - drawing 20, and explanation is omitted.
[0063] Moreover, it is possible to combine the configuration which removes an unnecessary component on the strength using the signal with which drawing 4, drawing 6, and drawing 7 differ from a phase as shown in drawing 8 in addition to this, and the configuration which offsets frequency fluctuation using a pilot signal as shown in drawing 10 - drawing 13, and to combine with them the configuration which reduces distortion by the PURIDISU torsion circuit further shown in drawing 15 (a) and drawing 15 (b). Moreover, it is possible to combine the configuration which removes an unnecessary component on the strength using the signal with which drawing 4, drawing 6, and drawing 7 differ from a phase as shown in drawing 8, and the configuration which reduces distortion by the PURIDISU torsion circuit shown in drawing 15 (a) and drawing 15 (b), and to combine with them the configuration which reduces optical frequency fluctuation by AFC further shown in drawing 16 (a) and drawing 16 (b).

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] Drawing 1 (a) is the whole lightwave signal transmission equipment block diagram of 1 operation gestalt of this invention, drawing 1 (b) is the block diagram showing the internal configuration of the AM/FM converter 11 shown in drawing 1 (a), and drawing 1 (c) is the block diagram showing the internal configuration of ONU3 shown for showing in drawing 1 (a).
[Drawing 2] Drawing 2 (a) is drawing showing an example of the spectrum of the electric package FM modulation component obtained as an output of the optical-heterodyne-detection section 112 shown in drawing 1 (b), and drawing 2 (b) is drawing showing the spectrum of the recovery multi-channel AM video signal to which it restores collectively by FM recovery section 32 shown in drawing 1 (c).
[Drawing 3] the ratio of the power PFM of signal light (FM laser beam) and the power PLO of local oscillation light (local laser beam) which are inputted into the optical/electrical converter 112-3 which shows drawing 3 (a) and drawing 3 (b) to drawing 1 (b), respectively -- it is drawing showing the relation of PFM/PLO and CNR when restoring to a modulating signal to AM video signal in the output terminal of the AM/FM converter 11.
[Drawing 4] It is the block diagram showing other operation gestalten of the AM/FM converter by this invention.
[Drawing 5] the ratio of the power PFM of signal light (FM laser beam) and the power PLO of a local laser beam which show drawing 5 (a) and drawing 5 (b) to drawing 4 and by which an optical/electrical converter 112-3 HE input is carried out -- with PFM/PLO It is drawing showing the relation between secondary inphase composition machine 11 compound distortion (CSO) of AM video signal when restoring to an electric package conversion FM signal in the output terminal of B-4, and 3rd compound distortion (CTB) with a broken line. The property of the AM/FM converter 11 which aligns with each drawing and is shown in drawing 1 (b) as a continuous line is shown.

[Drawing 6] It is the block diagram showing other operation gestalten of the AM/FM converter by this invention.
[Drawing 7] It is the block diagram showing other operation gestalten of the AM/FM converter by this invention.
[Drawing 8] It is the block diagram showing other operation gestalten of the AM/FM converter by this invention.
[Drawing 9] It is the block diagram showing the whole lightwave signal transmission equipment configuration of 1 operation gestalt of this invention.
[Drawing 10] It is the block diagram showing the internal configuration of AM/FM converter 11K shown in drawing 9.
[Drawing 11] It is the block diagram showing other operation gestalten of AM/FM converter 11K shown in drawing 9.
[Drawing 12] It is the block diagram showing other operation gestalten of AM/FM converter 11K shown in drawing 9.
[Drawing 13] It is the block diagram showing other operation gestalten of AM/FM converter 11K shown in drawing 9.
[Drawing 14] It is drawing showing the spectrum in (G) from each part (A) of each example of a configuration of the AM/FM converter shown in drawing 10 - drawing 13.
[Drawing 15] The block diagram showing other operation gestalten of the lightwave signal transmission equipment according [drawing 15 (a)] to this invention and drawing 15 (b) are the block diagrams showing the example of a configuration of the PURIDISU torsion circuit 6 shown in drawing 15 (a).
[Drawing 16] Drawing 16 (a) and drawing 16 (b) are the block diagrams showing the modification of the AM/FM converter 11 shown in drawing 1, respectively.
[Drawing 17] It is the block diagram showing the example of combination of each operation gestalt by this

invention.
[Drawing 18] It is the block diagram showing the example of combination of each operation gestalt by this invention.
[Drawing 19] It is the block diagram showing the example of combination of each operation gestalt by this invention.
[Drawing 20] It is the block diagram showing the example of combination of each operation gestalt by this invention.
[Description of Notations]
1 SLT
2 Optical Transmission Line
3 ONU
4 TV Receiving Set
5 Multiplexing Machine
6 PURIDISU Torsion Circuit
11 AM/FM Converter
12 DFB Laser
31 APD (Optical/electrical Converter)
32 FM Recovery Section
111 Optical Frequency Modulation Section
111-1 FM Laser
112 Optical-Heterodyne-Detection Section
112-1 Optical Frequency Local Oscillator
112-2 Optical Multiplexing Machine
112-10 Local Laser
112-3 Optical/electrical Converter
11B-1 A differential distributor
11B-2 Amplitude regulator
11B-3 Time delay regulator
11B-4 Inphase composition machine
112C-3 Optical/electrical converter (balance DORESHIBA configuration)
11C-6 Optical intensity modulator
11C-1 An optical turnout
11C-2 PD
11C-3 Amplitude controller
11C-4 Time delay regulator
11C-5 Phase inverter
11E-1, 11E-2 Band pass filter
11E-3 Frequency mixer
201 Low Pass Filter (LPF)
202 AFC
203 FM Recovery Section (Frequency Recovery Section)

[Translation done.]

(19)日本国特許庁（ＪＰ）　(12)特　許　公　報（Ｂ２）　(11)特許番号
特許第3371355号
(P3371355)

(45)発行日　平成15年１月27日(2003.1.27)　(24)登録日　平成14年11月22日(2002.11.22)

(51)Int.Cl.⁷	識別記号	ＦＩ	
Ｈ０４Ｂ　10/04		Ｈ０４Ｎ　7/22	
10/02		Ｈ０４Ｂ　9/00	Ｌ
10/06			Ｍ
10/142			
10/152			

請求項の数６（全 19 頁）　最終頁に続く

(21)出願番号　特願平8－176813
(22)出願日　平成８年７月５日(1996.7.5)
(65)公開番号　特開平9－326769
(43)公開日　平成９年12月16日(1997.12.16)
審査請求日　平成12年12月15日(2000.12.15)
(31)優先権主張番号　特願平8－84093
(32)優先日　平成８年４月５日(1996.4.5)
(33)優先権主張国　日本（ＪＰ）

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(54)【発明の名称】　変調方式変換回路及び光信号伝送装置

1　2

(57)【特許請求の範囲】
【請求項１】　電気信号を入力し、光周波数変調した信号光を出力する光周波数変調手段と、
前記信号光と所定の中間周波数だけ離れた光周波数の局部発振光を出力する光周波数発振手段と、前記信号光と前記局部発振光とを合波する光合波手段と、前記光合波手段の出力を電気信号に変換して出力する光電変換手段とを備え、前記信号光を入力して前記中間周波数へ周波数変換した変調信号を出力する光ヘテロダイン検波部と、
前記光周波数変調手段において発生する、光周波数変調手段が発生する信号におけるＡＭ成分を除去する不要強度成分除去手段とを有し、
前記不要強度成分除去手段は、
前記光周波数変調手段に入力される電気信号を分配する分配手段と、
前記分配手段の出力の一つを前記光ヘテロダイン検波部の出力変調信号と逆相の関係で合波する合波手段とからなることを特徴とする変調方式変換回路。
【請求項２】　電気信号を入力し、光周波数変調した信号光を出力する光周波数変調手段と、
前記信号光と所定の中間周波数だけ離れた光周波数の局部発振光を出力する光周波数発振手段と、前記信号光と前記局部発振光とを合波する光合波手段と、前記光合波手段の出力を電気信号に変換して出力する光電変換手段とを備え、前記信号光を入力して前記中間周波数へ周波数変換した変調信号を出力する光ヘテロダイン検波部と、
前記光周波数変調手段において発生する、光周波数変調手段が発生する信号におけるＡＭ成分を除去する不要強

度成分除去手段とを有し、
前記不要強度成分除去手段は、
前記光周波数変調手段に入力される電気信号を分配する分配手段と、
前記分配手段の一つの出力によって前記光周波数変調手段の出力信号光を強度変調する光強度変調手段とからなることを特徴とする変調方式変換回路。

【請求項３】　電気信号を入力し、光周波数変調した信号光を出力する光周波数変調手段と、
前記信号光と所定の中間周波数だけ離れた光周波数の局部発振光を出力する光周波数発振手段と、前記信号光と前記局部発振光とを合波する光合波手段と、前記光合波手段の出力を電気信号に変換して出力する光電変換手段とを備え、前記信号光を入力して前記中間周波数へ周波数変換した変調信号を出力する光ヘテロダイン検波部と、
前記光周波数変調手段において発生する、光周波数変調手段が発生する信号におけるＡＭ成分を除去する不要強度成分除去手段とを有し、
前記不要強度成分除去手段は、
前記光周波数変調手段の出力信号光を２分岐する２分岐手段と、
前記２分岐手段の出力の一方を光強度変調して、光強度変調した出力を前記光ヘテロダイン検波部へ供給する光強度変調手段と、
前記２分岐手段のもう一方の出力を電気信号に変換し、変換した電気信号を前記光強度変調手段に逆相で変調信号として入力するための光電変換器とからなることを特徴とする変調方式変換回路。

【請求項４】　電気信号を入力し、光周波数変調した信号光を出力する光周波数変調手段と、
前記信号光と所定の中間周波数だけ離れた光周波数の局部発振光を出力する光周波数発振手段と、前記信号光と前記局部発振光とを合成する光合波手段と、前記光合波手段の出力を電気信号に変換して出力する第１の光電変換手段とを備え、前記信号光を入力して前記中間周波数へ周波数変換した変調信号を出力する光ヘテロダイン検波部と
からなる変調方式変換回路と、
前記変調方式変換回路の出力によって強度変調した送信光を出力する送信手段とからなる光送信装置と、
光伝送路と、
前記光送信装置に前記光伝送路を介して接続され、第２の光電変換手段と、前記第２の光電変換手段の出力を周波数復調する周波数復調手段とからなる光受信装置とを備える光信号伝送装置において、
前記光周波数変調手段において発生する、光周波数変調手段が発生する信号におけるＡＭ成分を除去する不要強度成分除去手段を備え、
前記不要強度成分除去手段は、
前記光周波数変調手段に入力される電気信号を分配する分配手段と、
前記分配手段の出力の一つを前記光ヘテロダイン検波部の出力変調信号と逆相の関係で合波する合波手段とからなることを特徴とする光信号伝送装置。

【請求項５】　電気信号を入力し、光周波数変調した信号光を出力する光周波数変調手段と、
前記信号光と所定の中間周波数だけ離れた光周波数の局部発振光を出力する光周波数発振手段と、前記信号光と前記局部発振光とを合成する光合波手段と、前記光合波手段の出力を電気信号に変換して出力する第１の光電変換手段とを備え、前記信号光を入力して前記中間周波数へ周波数変換した変調信号を出力する光ヘテロダイン検波部とからなる変調方式変換回路と、
前記変調方式変換回路の出力によって強度変調した送信光を出力する送信手段とからなる光送信装置と、
光伝送路と、
前記光送信装置に前記光伝送路を介して接続され、第２の光電変換手段と、前記第２の光電変換手段の出力を周波数復調する周波数復調手段とからなる光受信装置とを備える光信号伝送装置において、
前記光周波数変調手段において発生する、光周波数変調手段が発生する信号におけるＡＭ成分を除去する不要強度成分除去手段を備え、
前記不要強度成分除去手段は、
前記光周波数変調手段に入力される電気信号を分配する分配手段と、
前記分配手段の一つの出力によって前記光周波数変調手段の出力信号光を強度変調する光強度変調手段とからなることを特徴とする光信号伝送装置。

【請求項６】　電気信号を入力し、光周波数変調した信号光を出力する光周波数変調手段と、
前記信号光と所定の中間周波数だけ離れた光周波数の局部発振光を出力する光周波数発振手段と、前記信号光と前記局部発振光とを合成する光合波手段と、前記光合波手段の出力を電気信号に変換して出力する第１の光電変換手段とを備え、前記信号光を入力して前記中間周波数へ周波数変換した変調信号を出力する光ヘテロダイン検波部とからなる変調方式変換回路と、
前記変調方式変換回路の出力によって強度変調した送信光を出力する送信手段とからなる光送信装置と、
光伝送路と、
前記光送信装置に前記光伝送路を介して接続され、第２の光電変換手段と、前記第２の光電変換手段の出力を周波数復調する周波数復調手段とからなる光受信装置とを備える光信号伝送装置において、
前記光周波数変調手段において発生する、光周波数変調手段が発生する信号におけるＡＭ成分を除去する不要強度成分除去手段を備え、
前記不要強度成分除去手段は、

前記光周波数変調手段の出力信号光を２分岐する２分岐手段と、

前記２分岐手段の出力の一方を光強度変調して、光強度変調した出力を前記光ヘテロダイン検波部へ供給する光強度変調手段と、

前記２分岐手段のもう一方の出力を電気信号に変換し、変換した電気信号を前記光強度変調手段に逆相で変調信号として入力するための光電変換器とからなることを特徴とする光信号伝送装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は広帯域信号の光伝送に利用する変調方式変換回路及び光信号伝送装置に関する。さらに詳しくは、本発明は、周波数分割多重されている振幅変調された多チャンネル映像信号を光伝送するのに適し、特に、パッシブダブルスター（ＰＤＳ）光加入者システムで利用するのに適した変調方式変換回路及び光信号伝送装置に関する。

【０００２】

【従来の技術】現在、各国において、多チャンネル映像信号を伝送する方法として、広帯域電気信号を光信号に変換して伝送する光伝送方式の研究開発が精力的に進められている。その一つに、振幅変調されている多チャンネル映像信号の振幅に比例して半導体レーザを強度変調し、その強度変調した光信号を光伝送する方式（以下ＡＭ－ＴＶ伝送方式という）がある。ＡＭ－ＴＶ伝送方式は、ケーブルテレビの幹線系光伝送に主に用いられている。ところが、ＡＭ－ＴＶ伝送方式は、雑音耐力が小さいため、送受間レベル差を大きくとることができず、光伝送系での伝送距離及び光分岐数を大きくとることができないという課題がある。

【０００３】この課題を解決するため、多チャンネル映像信号をチャンネル毎にあらかじめ周波数変調してから半導体レーザを強度変調して光伝送する方式（以下、映像チャンネル個別でのＦＭ－ＴＶ伝送方式という）が開発された。 映像チャンネル個別でのＦＭ－ＴＶ伝送方式は、雑音耐力が大きいため、送受間レベル差の大きな光伝送系において伝送距離及び光分岐数を大きくとることが可能である。しかしながら、この方式では、チャンネルを選択してから復調しなければならず、チャンネル選択回路が広帯域で複雑なものとなるため、受信器が高価になってしまうという課題があった。

【０００４】一方、これらと異なるものとして、多チャンネル映像信号を多チャンネルのまま一括して周波数変調してから半導体レーザを強度変調し、その変調信号光を光伝送し、受信側で一括して多チャンネル映像信号に復調する方式（以下一括ＦＭ－ＴＶ伝送方式という）が研究開発された。 一括ＦＭ－ＴＶ伝送方式は、雑音耐力が大きいため、送受間レベル差が大きい光伝送系において伝送距離及び光分岐数を大きくとることが可能である。しかも、光伝送される信号は広帯域ではあるが、高速ＩＣを用いることにより簡単な回路で復調でき、復調した信号からはケーブルテレビ用の汎用のチューナによってチャンネル選択できるので、受信器は安価に構成することができる。

【０００５】

【発明が解決しようとする課題】しかしながら、多チャンネル映像信号を一括して周波数変調する変調器は、従来、電圧制御発振器（以下、ＶＣＯと記す）を用いて構成されているため、ＶＣＯの入力周波数の帯域制限により変調することができる周波数帯域に限度がある。 一般にＶＣＯの入力インピーダンスは高周波において大きくなるので、ＶＣＯへ入力できる電気信号はおよそ200MHzが限界である。テレビ放送の伝送に使用可能な周波数帯域の下限はラジオ放送の周波数（例えば90MHz）によって制限されるため、ＶＣＯを使用する場合には、90～200MHz程度の帯域がテレビ放送の伝送のために使用できる周波数帯域となる。例えば、テレビ放送の１チャンネル当たりの伝送に必要な伝送帯域幅を6MHzとすると、ＶＣＯを使用する場合には同時に伝送できる映像チャンネルの数が２０チャンネル程度となる。さらに、広い周波数帯域に渡って線形性を維持するＶＣＯを作製することは困難であるという作製上の問題もある。

【０００６】この発明は、このような背景の下になされたもので、周波数帯域を従来に比べ広帯域化でき、歪みや雑音の少ない高品質な信号伝送を可能とする変調方式変換回路及びそれを用いた光信号伝送装置を提供することを目的とする。

【０００７】

【課題を解決するための手段】上記課題を解決するため、請求項１記載の発明は、電気信号を入力し、光周波数変調した信号光を出力する光周波数変調手段と、前記信号光と所定の中間周波数だけ離れた光周波数の局部発振光を出力する光周波数発振手段と、前記信号光と前記局部発振光とを合波する光合波手段と、前記光合波手段の出力を電気信号に変換して出力する光電変換手段とを備え、前記信号光を入力して前記中間周波数へ周波数変換した変調信号を出力する光ヘテロダイン検波部と、前記光周波数変調手段において発生する、光周波数変調手段が発生する信号におけるＡＭ成分を除去する不要強度成分除去手段とを有し、前記不要強度成分除去手段は、前記光周波数変調手段に入力される電気信号を分配する分配手段と、前記分配手段の出力の一つを前記光ヘテロダイン検波部の出力変調信号と逆相の関係で合波する合波手段とからなることを特徴とする変調方式変換回路である。

【０００８】また、請求項２記載の発明は、電気信号を入力し、光周波数変調した信号光を出力する光周波数変調手段と、前記信号光と所定の中間周波数だけ離れた光周波数の局部発振光を出力する光周波数発振手段と、前

記信号光と前記局部発振光とを合波する光合波手段と、前記光合波手段の出力を電気信号に変換して出力する光電変換手段とを備え、前記信号光を入力して前記中間周波数へ周波数変換した変調信号を出力する光ヘテロダイン検波部と、前記光周波数変調手段において発生する、光周波数変調手段が発生する信号におけるＡＭ成分を除去する不要強度成分除去手段とを有し、前記不要強度成分除去手段は、前記光周波数変調手段に入力される電気信号を分配する分配手段と、前記分配手段の一つの出力によって前記光周波数変調手段の出力信号光を強度変調する光強度変調手段とからなることを特徴とする変調方式変換回路である。

【０００９】また、請求項３記載の発明は、電気信号を入力し、光周波数変調した信号光を出力する光周波数変調手段と、前記信号光と所定の中間周波数だけ離れた光周波数の局部発振光を出力する光周波数発振手段と、前記信号光と前記局部発振光とを合波する光合波手段と、前記光合波手段の出力を電気信号に変換して出力する光電変換手段とを備え、前記信号光を入力して前記中間周波数へ周波数変換した変調信号を出力する光ヘテロダイン検波部と、前記光周波数変調手段において発生する、光周波数変調手段が発生する信号におけるＡＭ成分を除去する不要強度成分除去手段とを有し、前記不要強度成分除去手段は、前記光周波数変調手段の出力信号光を２分岐する２分岐手段と、前記２分岐手段の出力の一方を光強度変調して、光強度変調した出力を前記光ヘテロダイン検波部へ供給する光強度変調手段と、前記２分岐手段のもう一方の出力を電気信号に変換し、変換した電気信号を前記光強度変調手段に逆相で変調信号として入力するための光電変換器とからなることを特徴とする変調方式変換回路である。

【００１０】また、請求項４記載の発明は、電気信号を入力し、光周波数変調した信号光を出力する光周波数変調手段と、前記信号光と所定の中間周波数だけ離れた光周波数の局部発振光を出力する光周波数発振手段と、前記信号光と前記局部発振光とを合成する光合波手段と、前記光合波手段の出力を電気信号に変換して出力する第１の光電変換手段とを備え、前記信号光を入力して前記中間周波数へ周波数変換した変調信号を出力する光ヘテロダイン検波部とからなる変調方式変換回路と、　前記変調方式変換回路の出力によって強度変調した送信光を出力する送信手段とからなる光送信装置と、光伝送路と、前記光送信装置に前記光伝送路を介して接続され、第２の光電変換手段と、前記第２の光電変換手段の出力を周波数復調する周波数復調手段とからなる光受信装置とを備える光信号伝送装置において、前記光周波数変調手段において発生する、光周波数変調手段が発生する信号におけるＡＭ成分を除去する不要強度成分除去手段を備え、前記不要強度成分除去手段は、前記光周波数変調手段に入力される電気信号を分配する分配手段と、前記分配手段の出力の一つを前記光ヘテロダイン検波部の出力変調信号と逆相の関係で合波する合波手段とからなることを特徴とする光信号伝送装置である。

【００１１】また、請求項５記載の発明は、電気信号を入力し、光周波数変調した信号光を出力する光周波数変調手段と、前記信号光と所定の中間周波数だけ離れた光周波数の局部発振光を出力する光周波数発振手段と、前記信号光と前記局部発振光とを合成する光合波手段と、前記光合波手段の出力を電気信号に変換して出力する第１の光電変換手段とを備え、前記信号光を入力して前記中間周波数へ周波数変換した変調信号を出力する光ヘテロダイン検波部とからなる変調方式変換回路と、　前記変調方式変換回路の出力によって強度変調した送信光を出力する送信手段とからなる光送信装置と、光伝送路と、前記光送信装置に前記光伝送路を介して接続され、第２の光電変換手段と、前記第２の光電変換手段の出力を周波数復調する周波数復調手段とからなる光受信装置とを備える光信号伝送装置において、前記光周波数変調手段において発生する、光周波数変調手段が発生する信号におけるＡＭ成分を除去する不要強度成分除去手段を備え、前記不要強度成分除去手段は、前記光周波数変調手段に入力される電気信号を分配する分配手段と、前記分配手段の一つの出力によって前記光周波数変調手段の出力信号光を強度変調する光強度変調手段とからなることを特徴とする光信号伝送装置である。

【００１２】また、請求項６記載の発明は、電気信号を入力し、光周波数変調した信号光を出力する光周波数変調手段と、前記信号光と所定の中間周波数だけ離れた光周波数の局部発振光を出力する光周波数発振手段と、前記信号光と前記局部発振光とを合成する光合波手段と、前記光合波手段の出力を電気信号に変換して出力する第１の光電変換手段とを備え、前記信号光を入力して前記中間周波数へ周波数変換した変調信号を出力する光ヘテロダイン検波部とからなる変調方式変換回路と、　前記変調方式変換回路の出力によって強度変調した送信光を出力する送信手段とからなる光送信装置と、光伝送路と、前記光送信装置に前記光伝送路を介して接続され、第２の光電変換手段と、前記第２の光電変換手段の出力を周波数復調する周波数復調手段とからなる光受信装置とを備える光信号伝送装置において、前記光周波数変調手段において発生する、光周波数変調手段が発生する信号におけるＡＭ成分を除去する不要強度成分除去手段を備え、前記不要強度成分除去手段は、前記光周波数変調手段の出力信号光を２分岐する２分岐手段と、前記２分岐手段の出力の一方を光強度変調して、光強度変調した出力を前記光ヘテロダイン検波部へ供給する光強度変調手段と、前記２分岐手段のもう一方の出力を電気信号に変換し、変換した電気信号を前記光強度変調手段に逆相で変調信号として入力するための光電変換器とからなることを特徴とする光信号伝送装置である。

【００１３】
【００１４】
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【００１９】
【００２０】
【００２１】
【００２２】
【００２３】
【００２４】
【発明の実施の形態】本発明が適用される光信号伝送装置は、図1(a)～図1(c)にその一構成例を示すように、広帯域ＡＭ入力信号で変調された半導体ＦＭレーザの光ＦＭ変調成分を光ヘテロダイン検波により電気ＦＭ変調成分として抽出して、送信用光源を強度変調し光伝送路に送信する。図1(a)は光信号伝送装置100の全体構成を示すブロック図である。 光信号伝送装置100は、ＳＬＴ（加入者線端末）1、光伝送路2、ＯＮＵ（光網終端装置）3、及びテレビ受像機4から構成されている。ただし、ＯＮＵ3から出力されるＡＭ映像信号を受信するテレビ受像機4は、例えば受信部を有するビデオテープレコーダ等の機器に置き換えることが可能である。さらに、テレビ受像機4を含まない構成も、本発明による光信号伝送装置の一態様として考えることができる。なお、このような光信号伝送装置の概要は、本出願の発明者による"Optical Super Wide-Band FM Modulation Scheme and Its Application to Multi-Channel AM Video Transmission Systems", International Conference on Integrated Optics and Optical FIbre Communication, IOOC-95, June26-30, 1995, Technical Digest, volume 5 - Postdeadline Papersに記載されている。

【００２５】図1(a)に示すＳＬＴ1は、ＡＭ／ＦＭ（振幅変調／周波数変調）コンバータ11とＤＦＢ（分布帰還）レーザ12から構成されている。ＳＬＴ1は、周波数分割多重された多チャンネルのＡＭ映像信号を入力し、一括してＦＭ映像信号に変換し、変換した多チャンネル映像信号によって強度変調された光伝送信号として光伝送路2上へ送信する。 光伝送路２は、光ファイバ20、光スターカプラ21、光スターカプラ21の分岐出力に接続された複数の光ファイバ22を用い、１対多数の通信を可能にするパッシブダブルスター（ＰＤＳ）方式によって光信号を伝送する。ＯＮＵ３は、光電変換及びＦＭ／ＡＭコンバータ30によって、光伝送路２を介して伝送されてきた光伝送信号を受信して、光電変換し、ＡＭ映像信号に復調して出力する。 テレビ受像機４は、ＯＮＵ３から出力されるＡＭ映像信号を受信し、複数チャネルの中からユーザーによって選択された任意のチャンネルの映像を映し出す。

【００２６】図1(b)は、図1(a)に示すＡＭ／ＦＭコンバータ11の内部構成を示すブロック図である。ＡＭ／ＦＭコンバータ11は光周波数変調部111と光ヘテロダイン検波部112から構成されている。光周波数変調部111は半導体ＦＭレーザ111-1を含んでいる。光ヘテロダイン検波部112は半導体ローカルレーザ112-10からなる光周波数局部発振器112-1と光合波器112-2とＰＤ（フォトダイオード）からなる光電変換器112-3を備えている。一方、光電変換及びＦＭ／ＡＭコンバータ30は、図1(c)に示すようにＡＰＤ（アバランシュフォトダイオード）からなる光電変換器31とＦＭ復調部32から構成されている。ＦＭ復調部32は、反転非反転増幅器32-1、遅延線32-2、排他的論理和回路32-3、及びローパスフィルタ32-4を用い、光電変換器31で電気信号に変換したＦＭ電気信号を遅延検波によってＡＭ電気信号に復調する。

【００２７】以上の構成によって、図1に示す光信号伝送装置は、周波数分割多重された多チャンネルのＡＭ映像信号をＳＬＴ1へ入力し、この入力信号によって半導体ＦＭレーザ111-1をＦＭ変調する。光ヘテロダイン検波部112は、光周波数局部発振器112-1と光合波器112-2を用い光ヘテロダイン検波技術によって広帯域ＡＭ入力信号で変調された半導体ＦＭレーザ111-1の出力から光周波数変調成分を得て、さらに光電変換器112-3で光電変換して、電気一括ＦＭ変調成分を抽出する。ＤＦＢレーザ12を用いた送信用光源は、光電変換器112-3から出力される電気一括ＦＭ変調成分によって強度変調され、強度変調された光信号が光伝送路2へ送信される。一方、受信側では、ＯＮＵ3において、光伝送路2を介して伝送されてきた光伝送信号を光電変換器31で受信して光電変換する。そして、ＦＭ復調部32において遅延検波によりＡＭ映像信号に復調する。

【００２８】図2(a)に光ヘテロダイン検波部112の出力として得られる電気一括ＦＭ変調成分のスペクトルの一例を、図2(b)にＦＭ復調部32によって一括して復調される復調多チャンネルＡＭ映像信号のスペクトルを示す。図2(a)は、電気一括ＦＭ変調成分のスペクトルの中心周波数、すなわち中間周波数は1.75GHzの場合を示している。図2(b)は、４０チャンネルのＡＭ映像信号を復調する場合を示している。

【００２９】図1(a)～1(c)に示す構成の光信号伝送装置をケーブルテレビシステムに応用する場合、数十チャンネルのＡＭ映像信号を一括してひとつのＦＭ信号に変換し、これを光伝送路に送出し、受信側でこのＦＭ伝送信号を遅延検波等によって一括して多チャンネルＡＭ映像信号に復調することが可能となる。すなわち、以上の構成によれば、従来ＶＣＯを利用した一括ＦＭ－ＴＶ伝送方式では実現することが困難であった広周波数帯域の信号伝送が可能となる。しかしながら、上述した光信号伝送装置を実用するに当たっては、雑音を減少させ、高品質な信号伝送を可能とするため、以上の構成に加えて、

さらに以下に説明する本発明による各構成を採用することが望まれる。

【００３０】図1(a)及び図1(c)に示す構成が含まれる一括ＦＭ－ＴＶ伝送方式においては、ＯＮＵ3内の光電変換及びＦＭ／ＡＭコンバータ30の出力端子（すなわち、ＦＭ復調部32の出力端子）における出力信号をＡＭ映像信号に復調したときに得られるＣＮＲ（Carrier to Noise Ratio：搬送波対雑音比）の値が、伝送するチャンネル数に依存することが分かっている。つまりＣＮＲはチャンネル数を減らすことによって改善することが可能である。しかし、ＣＮＲの改善を目的としてチャンネル数を減らした場合には、上記の構成によって得られる広周波数帯域の信号伝送という作用効果が十分に生かされなくなってしまう。そのため、チャンネル数を減らすことなくＣＮＲの改善ができる技術が望まれていた。これに対して本発明は、チャンネル数を減らすことなくＣＮＲを改善することができる変調方式変換回路及び光信号伝送装置を提供することを詳細な目的とし、そのための構成を提供するものである。

【００３１】図3(a)及び図3(b)は、図1(b)に示す光ヘテロダイン検波部112において光電変換器112-3へ入力される信号光（ＦＭレーザ光）のパワーP_{FM}と光周波数局部発振器112-1から出力される局部発振光（ローカルレーザ光）のパワーＰＬＯとの比P_{FM}/P_{LO}と、ＡＭ／ＦＭコンバータ11の出力端子において変調信号をＡＭ映像信号に復調したときのＣＮＲの関係を示す。ここで、図3(a)はＦＭ信号スペクトルの中心周波数すなわち中間周波数が2.75GHzの場合の測定値を示し、図3(b)は3.85GHzの場合の測定値を示す。どちらも２０チャンネルの伝送特性である。また、１チャネル当たりの周波数偏移Δfは中間周波数が2.75GHzと3.85GHzのときに、それぞれ220MHz$_{0-p}$/ch、280MHz$_{0-p}$/chである。

【００３２】これらの図に示すように、ＡＭ映像信号のＣＮＲは、ＦＭレーザ光のパワーP_{FM}とローカルレーザ光のパワーP_{LO}の比P_{FM}/P_{LO}の値に依存して変化する。さらに、ＣＮＲとパワー比P_{FM}/P_{LO}の関係は中間周波数の大きさによって変化する。 また、図3(a)、図3(b)から、ＣＮＲが最大となるのは、光パワー比が０ｄＢ近傍であることがわかる。したがって、パワーP_{FM}とパワーP_{LO}の比P_{FM}/P_{LO}を所望の範囲に制御することで、所望のＣＮＲを得ることが可能となる。

【００３３】ところで、現在、ＣＮＲに関する同軸ＣＡＴＶでの伝送品質の規格は４２ｄＢ以上となっている。また、実際にパワー比P_{FM}/P_{LO}を制御するに当たっては、ＦＭレーザ光のパワーP_{FM}とローカルレーザ光のパワーP_{LO}それぞれについて設計値に対しての初期製造偏差を±４ｄＢ程度見込む必要がある。したがって、これらの条件を考慮し、図3(a)及び図3(b)に示す特性に基づいて考えると、安定した品質でかつ伝送品質の規格４２ｄＢ以上を満足するＣＮＲの特性を得るためには、P_{FM}/P_{LO}の比を$-8 < P_{FM}/P_{LO} < 8$［ｄＢ］に制御することが望ましい。

【００３４】次に、図1(a)及び図1(b)に示す光信号伝送装置のＡＭ／ＦＭコンバータ11の本発明による他の実施形態を、図2(a)並びに図4～図8を参照して説明する。上述した図1(b)に示す光周波数変調部111では、半導体レーザによって構成されるＦＭレーザ111-1の注入電流を入力信号に応じて変化させることによって出力するＦＭレーザ光に光周波数変調をかけている。しかしながら、この場合、ＦＭレーザ光には注入電流の変化によって光強度変調もかかってしまうので、光ヘテロダイン出力には、図2(a)の電気一括ＦＭ変調信号スペクトルに示すようにＦＭ成分だけでなく、同時にＡＭ変調成分が混在することになる。一方、ＦＭ変調成分については、そのスペクトルが中間周波数（図2(a)の例では1.75GHz）を中心に対称形になるのが理想的なＦＭ変調である。しかし、実際にはＦＭレーザ光には周波数変調だけでなく強度変調が同時にかかってしまうので、スペクトルは非対称になる。また、ＦＭレーザ光あるいはローカルレーザ光の振幅にはゆらぎがあり、これらはＦＭ復調部32によって復調すると歪みや雑音になるため、映像品質が劣化させせる原因となる恐れがある。 また、ＦＭレーザ光の光周波数のゆらぎやローカルレーザ光の光周波数のゆらぎも、ＦＭ復調部32により復調するとやはり雑音になるため、映像品質が劣化する原因となる恐れがある。そこで以下に示す本発明による実施形態は、その対策を図り、さらに歪みや雑音の少ない高品質な信号伝送を可能とするものである。

【００３５】図4は、図1(a)に示すＡＭ／ＦＭコンバータ11の本発明による他の実施形態を示す。 図4において、図1(a)又は図1(b)に示す構成と同一のものには同一の符号を付けている。なお、下記に示す他の実施形態においても同様に同一の構成には同一の符号を付ける。この図に示すＡＭ／ＦＭコンバータ11Bは、入力ＡＭ映像信号の位相を180°異ならせて分配する差動分配器11B-1と、差動分配器11B-1の２つの出力のうち一方の電気信号を入力してその振幅を調整する振幅調整器11B-2と、振幅調整器11B-2の出力電気信号に遅延を与える遅延時間調整器11B-3と、遅延時間調整器11B-3の出力電気信号と、差動分配器11B-1の他方の出力に基づく電気一括ＦＭ変調成分とを同相で合成する同相合成器11B-4を新たに備えている。 ＡＭ／ＦＭコンバータ11Bでは、ＡＭ映像信号を差動分配器11B-1によって位相を0°と180°の逆相の関係で分配し、一方の出力（位相；0°）をＦＭレーザ111-1に入力し、その出力を光ヘテロダイン検波部112へ供給する。光ヘテロダイン検波部112は、入力された光信号を光ヘテロダイン検波して、さらにＰＤ112-3によって電気信号に変換して周波数変調信号を出力する。 ＰＤ112-3から出力される電気信号と、差動分配器11B-1のもう一方の出力（位相；180°）に基づく電気信号

は、同相合成器11B-4によって同相合成される。このとき位相180°側から同相合成器11B-4に入力される電気信号は、光周波数変調信号光のＡＭ変調成分と同量の振幅で逆相になるように、振幅調整器11B-2で振幅調整され、さらに遅延時間調整器11B-3によって遅延時間調整される。したがって、同相合成器11B-4の各入力信号は、同相合成器11B-4において各々のＡＭ変調成分を相殺する。ＰＤ112-3の出力のスペクトルを図中(1)に、遅延時間調整器11B-3の出力のスペクトルを(2)に示した。なお、ここでは、逆相成分を分配して同相合成を行う構成を示したが、同相で分配し、差動合成を行う構成に変更することもできる。この変更は、後で述べる図7や図11に示す実施形態においても同様に可能である。

【００３６】ここで、図5(a)及び図5(b)を参照して、図4に示すＡＭ／ＦＭコンバータ11Bにおける光電変換器112-3へ入力される信号光（ＦＭレーザ光）のパワーP_{FM}とローカルレーザ光のパワーP_{Lo}との比P_{FM}/P_{Lo}と、同相合成器11B-4の出力端子において電気一括変換ＦＭ信号を復調したときのＡＭ映像信号の複合２次歪み（ＣＳＯ：Composite Second-Order Distortion）及び複合３次歪み（ＣＴＢ：Composite Triple Beat Distortion）の関係について説明する。

【００３７】図5(a)はＦＭ信号スペクトルの中心周波数すなわち中間周波数が2.75GHzの場合の測定値、図5(b)は3.85GHzの場合の測定値をそれぞれ示している。そして、どちらの図も２０チャンネルの伝送特性を示している。図5(a)、5(b)において、実線で示す特性が図1(b)に示すＡＭ／ＦＭコンバータ11の特性であり、破線で示す特性が図4に示すＡＭ／ＦＭコンバータ11Bの特性である。なお、１チャネル当たりの周波数偏移Δｆは中間周波数が2.75GHzと3.85GHzのとき、それぞれ、220MHz$_{0-p}$/chと280MHz$_{0-p}$/chである。このように、図4に示す構成によれば、ＡＭ成分を除去することによって、図5(a)に示す場合では矢印で示すようにP_{FM}/P_{Lo}の値を変えないままＣＳＯを改善することができる。また、図5(b)の場合は矢印で示すようにP_{FM}/P_{Lo}の値を変えないまま、ＣＳＯとＣＴＢの両方を改善することができる。したがって、ＡＭ成分除去と上述した光パワー比の所定範囲の制御を適用することによって、ＣＮＲと歪み（ＣＳＯ、ＣＴＢ）の両方を改善することが可能である。

【００３８】図6は、図4を参照して説明したＡＭ／ＦＭコンバータ11Bと同様にＡＭ成分除去するための実施形態の他の構成を示すブロック図である。図6に示すＡＭ／ＦＭコンバータ11Cでは、バランスドレシーバ構成とした光電変換器112C-3を用いて光ヘテロダイン検波部112Cを構成している。光ヘテロダイン検波部112Cでは、特性の一致した２つのＰＤから光電変換器112C-3が構成されていて、また、光合波器112-2から２つのＰＤまでの光路長は一致している。この場合、光電変換器112C-3では、強度変調成分が同相で受信され、周波数変調成分が逆相で受信される。２つのＰＤのそれぞれの極性が互いに逆になるように光電変換器112C-3が構成されているため、そこでは強度変調成分が相殺され、周波数変調成分が足し合わされる。

【００３９】この場合、バランスドレシーバ構成とすることの特長の１つは、ＦＭレーザ光の強度変調成分と強度ゆらぎだけでなく、ローカルレーザ光の強度変調成分と強度ゆらぎをも相殺することができる点である。もう１つの特長は、例えば方向性結合器からなる光合波器112-2の出力を２つとも利用していることである。これによれば、上述したように周波数変調成分が足し合わされるので、光パワーを有効に利用することができる。なお、バランスドレシーバについては、例えば次の参考文献Kiyoshi Nosu, Katsushi Iwashita, Nori Shibata, Masao Kawachi, Hiromu Toba, Osamu Ishida, Takeshi Ito, and Kyo Inoue, "Coherenct Lightwave Communications Technology", pp.76-79, Chapman & Hall, London, 1995に詳しく説明されている。

【００４０】図4の構成と図6の構成を比べると、図4の構成は、バランスドレシーバを用いた図6の構成に比べて、安価であるという長所がある。というのも用いている差動分配器11B-1、振幅調整器11B-2、及び遅延時間調整器11B-3は、すべて多チャンネル映像信号の周波数、例えば0MHz以上、350MHz以下で動作すれば良く、用いられる電子部品が安価であるからである。唯一安価ではないのは、高周波（一括ＦＭ信号の周波数）となる同相合成器11B-4であるが、バランスドレシーバに比べればやはり安価である。一方、バランスドレシーバは高周波で動作する光電変換器（PD）が２つ必要なので、図4に示す構成と比較すると高価になる。従来の光信号伝送システムにおいては、通常、光送信部（図1(a)に示すＳＬＴ1に対応する構成）と光受信部（図1(a)に示すＯＮＵ3に対応する構成）は、長い光伝送路をはさんで離れて設置されている。このような構成では、光受信部において長い光伝送路を通過してきた光信号のみを用いて光ヘテロダイン検波を行うことが望ましい。バランスドレシーバは、このような構成において、高品質な復調信号を得るために用いられている。

【００４１】これに対して、図4の構成は、光電変換器112-3の出力と、ＦＭレーザ111-1の変調信号に基づく電気信号とを利用してＡＭ成分除去する。従来の構成において、この構成を採用しようとする場合、ＡＭ変調成分用の信号伝送路を別に敷設する必要があったり、受信部に新たな装置を設置する必要が生じてしまう。本発明による図4に示すＡＭ／ＦＭコンバータ11Bの構成では、ＦＭレーザ111-1と光ヘテロダイン検波部112を構成する各構成要素112-10,112-2,112-3のすべてが送信側のＳＬＴ1内に設置され、至近距離にあるので、ＦＭレーザ111-1への入力を分配した電気信号と光ヘテロダイン検波部112の出力電気信号を簡易な構成で合成することが可能で

ある。そのため、従来の構成では困難であった、バランスドレシーバを用いた構成より安価であるという長所を生かすことが可能である。

【００４２】一方、図6に示したバランスドレシーバを用いる構成の長所は、相殺できる強度成分がＦＭレーザのものだけでなく、ローカルレーザのものも含むことができる点である。ただし、この点については、ＦＭレーザ111-1とＰＤ112-3の間の距離が比較的、短い場合には、図4のような構成においても、局部発振光パワー（ローカルレーザ112-2の出力）を低くすることができるので、ローカルレーザ光の強度ゆらぎの影響を小さくすることでバランスドレシーバを用いる場合と同様の特性を得ることが期待できる。

【００４３】次に図7を参照して図4に示すＡＭ／ＦＭコンバータ11Bの他の変形例について説明する。図7に示すＡＭ／ＦＭコンバータ11Dは、図4に示すＡＭ／ＦＭコンバータ11Bが備える差動分配器11B-1、振幅調整器11B-2、遅延時間調整器11B-3、及び光ヘテロダイン検波部112の各構成に加え、新たに遅延時間調整器11B-3の出力によってＦＭレーザ光を光強度変調する光強度変調器11C-6を有している。この実施形態では、ＦＭレーザ111-1の入力を作動分配器11B-1で0°と180°に２分岐しておき、180°側の信号を使って0°側の光信号を強度変調し、ＡＭ変調成分を相殺する。

【００４４】図8は、図4に示すＡＭ／ＦＭコンバータ11Bの他の変形例を示すブロック図である。図8に示すＡＭ／ＦＭコンバータ11Eには、ＦＭレーザ111-1の出力を２分岐する光分岐器11C-1、光分岐器11C-1の一方の出力光を電気信号に変換するＰＤ11C-2、その出力電気信号の振幅及び遅延時間を調整する振幅調節器11C-3及び遅延時間調整器11C-4、遅延時間調整器11C-4の出力を反転する位相反転器11C-5、ならびに光分岐器11C-1のもう一方の出力光を位相反転器11C-5の出力で光強度変調する光強度変調器11C-6が新たに設けられている。そして、ＡＭ／ＦＭコンバータ11Eでは、光強度変調器11C-6の出力光を光ヘテロダイン検波部112で検波して電気一括ＦＭ変調成分を得ている。

【００４５】図8に示すＡＭ／ＦＭコンバータ11Eでは、ＦＭレーザ111-1において入力ＡＭ映像信号によって変調された光周波数変調信号光を光分岐器11C-1で２分岐し、一方を光強度変調器11C-6に入力し、もう一方をＰＤ11C-2によって電気信号に変換した後、最終的に光強度変調器11C-6に逆相で入力して光分岐器11C-1の他の出力光を強度変調することによって、光強度変調器11C-6の出力光のＡＭ変調成分を相殺する。この場合、振幅調整器11C-3と遅延時間調整器11C-4では、ＡＭ変調成分が相殺され、かつＦＭ変調成分のスペクトルが中間周波数を中心にできる限り対称形となるように、光強度変調器11C-6に入力される電気信号の振幅と位相が調整される。図7及び図8に示す実施形態では、図6に示すバランスドレシーバを用いた構成や図4に示す実施形態のようにＰＤを用いて光電変換した出力でＡＭ変調成分を相殺しているのと違い、ＦＭレーザ111-1からの送出された光信号の状態でＡＭ変調成分を相殺する。バランスドレシーバを用いた構成や図4に示した構成の場合には、中間周波数に含まれるＡＭ変調成分や強度ゆらぎを相殺することができない。これに対して、図7及び図8の構成では、光の段階でＡＭ変調成分を相殺しているので、ＰＤの出力のすべての周波数にわたってＡＭ変調成分やＦＭレーザの強度ゆらぎを相殺することができる。ただし、図7及び図8の構成は、部品点数が増加するので、高価になる傾向があることと、ローカルレーザ112-10の局部発振光の強度ゆらぎが相殺できないので、この点については例えば図6に示す実施形態の方が優れているということができる。

【００４６】なお、図8に示す実施形態では、位相反転器11C-5を用いているが、ＰＤ11C-2の極性によって反転させることができるので、そのようにした場合には位相反転器11C-5を省略することができる。このことはあとから述べる図13に示す実施形態でも同様である。

【００４７】図9及び図10は、本発明による光信号伝送装置の他の実施形態を示すブロック図である。 図9及び図10に示す実施形態では、広帯域ＡＭ入力信号にパイロット信号を重畳してから半導体ＦＭレーザを変調する。そして、光ヘテロダイン検波によって得られたＦＭ変調信号とパイロット信号を、２つのバンドパスフィルタ11E-1及び11E-2によって抽出し、さらに周波数混合器11E-3によって周波数混合する。これによって、実施形態によれば、半導体ＦＭレーザの周波数のゆらぎ成分と局部発振用レーザの周波数ゆらぎ成分に起因する雑音を除去することができる。図9に示す光信号伝送装置101には、図1に示す光信号伝送装置100と比較して、ＡＭ映像信号に周波数が異なるパイロット信号を周波数多重する合波器５が新たに設けられている。この合波器5の出力はＳＬＴ1Fへ入力される。なお、パイロット信号を用いることによるゆらぎ成分の相殺については、次の参考文献で提唱されたものである［参考文献：Y.H.Cheng, T.Okoshi, "Phase-noise-cancelling dual-frequency heterodyne optical fibre communication system", Electronics Letter, vol.25, no.13, pp.835-836, 1989.］。

【００４８】ここで、ＡＭ／ＦＭコンバータ11Kの動作の詳細を図14を用いて説明する。 図14は、図10ならびに後述する図11、図12及び図13に示す各実施形態における各部(A)から(G)におけるスペクトルを示している。図9において、合波器５はＡＭ映像信号にパイロット信号を周波数多重する。ここでは、一例として、合波器5の出力(A)として、周波数90MHz～450MHzのＡＭ映像信号と周波数fp＝2.1GHzのパイロット信号が周波数多重された電気信号が得られるものと仮定する（図14の(A)）。図10に示す光周波数変調部111は、合波器5から入力される

電気信号(A)に応じた注入電流によってＦＭレーザ111-1を光ＦＭ変調し、例えば、中心周波数f1を193,006.1GHzとする光周波数変調信号を出力する（図14の(B)）。光周波数変調部111の出力(B)には、ＦＭ変調信号の中間周波数f1に対してＦＭレーザ111-1によるゆらぎ△f1が発生した周波数成分と、また、同じようにゆらぎ△f1を有するパイロット信号の周波数成分f1±fp（193,004.0GHz及び193,008.2GHz）を含む光信号が現れる。

【００４９】光ヘテロダイン検波部112は、光周波数変調部111からの光周波数変調信号光(B)を入力として、図14の(C)に示す光周波数局部発振器112-1からの局部発振光(C)（ここでは局部発振光周波数f2＝193,000GHzとする）を用いて光ヘテロダイン検波を行い、検波した電気信号を光電変換器112-3から出力する。図14の(D)は、光電変換器112-3から出力される電気ＦＭ一括変調成分(D)のスペクトルを示す。光周波数局部発振器112-1の出力はローカルレーザ112-10の局部発振光であり、発振周波数f2がゆらぎ成分△f2でゆらいだものとなっているので、電気ＦＭ一括変調成分(D)は、その中心周波数をＦＭレーザ111-1の中心発振周波数f1から局部発振周波数f2を引いたf1-f2として、さらにゆらぎ△f（＝△f1＋△f2）でゆらいだものとなる。また、電気ＦＭ一括変調成分(D)は、同時に、パイロット信号によるf1-f2±fpの周波数成分を含んでいる。この場合、電気ＦＭ一括変調成分(D)は、中心周波数f1-f2＝6.1GHzとパイロット信号によるf1-f2±fp＝8.2GHz, 4.0GHzの各周波数成分を含んだ信号となる。

【００５０】光周波数変調信号光(B)と局部発振光(C)の光周波数のゆらぎはそのまま電気信号(D)のゆらぎに変換される。また、一括ＦＭ変調成分の電気周波数のゆらぎとパイロット信号の電気周波数のゆらぎは同一（△f＝△f1＋△f2））になる。一括ＦＭ変調成分(D)とパイロット信号の一周波数成分を、バンドパスフィルタ11E-1、11E-2を用いてそれぞれ取り出した結果が図14の(E)及び(F)である。これらを周波数混合器11E-3によって周波数混合すると、周波数混合器11E-3からは、ゆらぎ成分が相殺された中心周波数をパイロット信号の周波数fpとする電気信号(G)を取り出すことができる（図14の(G)）。

【００５１】図11は、図9に示すＳＬＴ1F内のＡＭ／ＦＭコンバータ11Kの別の構成を示すブロック図である。ＡＭ／ＦＭコンバータ11Fでは、ＡＭ映像入力信号にパイロット信号を重畳した信号を差動分配器11B-1によって、位相を0°と180°の逆相の関係で分配し、その一方の出力（位相；0°）を光周波数変調部111に入力し、光ヘテロダイン検波部112から出力される電気信号と差動分配器11B-1のもう一方の出力（位相；180°）を同相合成器11B-4によって同相合成する。同相合成された出力は、２分岐され、２つのバンドパスフィルタ11E-1及び11E-2によってＦＭ信号変調成分とパイロット信号にそれぞれ分離される。分離されたこれら２つの電気信号は、周波数混合器11E-3内の乗算器によって周波数混合される。上述したように、周波数混合を行うことによって、光周波数変調信号光と局部発振光の光周波数のゆらぎを相殺する。図11に示すＡＭ／ＦＭコンバータ11Fによれば、パイロット信号を用いることによるゆらぎ成分の除去効果と、図4に示した実施形態と同様のＡＭ変調成分の相殺の効果を合わせて得ることができる。

【００５２】図12は、図9に示すＡＭ／ＦＭコンバータ11Kの他の実施形態を示す図である。図12に示すＡＭ／ＦＭコンバータ11Gは、図6に示すＡＭ／ＦＭコンバータ11Cと同様に構成されている光周波数変調部111と光ヘテロダイン検波部112Cを備え、新たにＦＭ変調信号成分を抽出するためのバンドパスフィルタ11E-1とパイロット信号を抽出するためのバンドパスフィルタ11E-2とそれらの出力を混合する周波数混合器11E-3を設けたものである。 ＡＭ／ＦＭコンバータ11Gでは、ＡＭ映像入力信号にパイロット信号を重畳した電気信号でＦＭレーザ111-1を変調する。そして、バランスドレシーバ112C-3によってＦＭレーザ111-1の出力光を光ヘテロダイン検波し、その検波出力を２分岐して２つのバンドパスフィルタ11E-1及び11E-2に入力し、ＦＭ信号変調成分とパイロット信号に分離する。さらに分離したこれら２つの電気信号を周波数混合器11E-3によって周波数混合し、光周波数変調信号光と局部発振光の光周波数のゆらぎを相殺する。この図に示す実施形態によれば、パイロット信号を用いることによるゆらぎ成分の除去効果と、図6に示した実施形態と同様のＦＭレーザ光の強度変調成分と強度ゆらぎと、ローカルレーザ光の強度変調成分と強度ゆらぎを相殺する効果を合わせて得ることができる。

【００５３】図13は、図9に示すＡＭ／ＦＭコンバータ11Kの他の実施形態を示す図である。図13に示すＡＭ／ＦＭコンバータ11Hは、ＡＭ映像入力信号にパイロット信号を重畳した電気信号でＦＭレーザ111-1を変調する。ＦＭレーザ111-1から出力される光周波数変調信号光は光分岐器11C-1で２分岐され、一方が光強度変調器11C-6に入力され、もう一方がＰＤ11C-2に入力されて電気信号に変換され、さらに振幅調整器11C-3、遅延時間調整器11C-4、及び位相反転器11C-5を介して光強度変調器11C-6に逆相で入力される。光強度変調器11C-6に入力された光信号を位相反転器11C-5から出力される電気信号によって強度変調することによって、光強度変調器11C-6の出力光におけるＡＭ変調成分が相殺される。この光強度変調器11C-6の出力光を光ヘテロダイン検波した検波出力(D)を２分岐して、２つのバンドパスフィルタ11E-1及び11E-2に入力し、ＦＭ信号変調成分(E)とパイロット信号(F)に分離する。そして、分離したこれら２つの電気信号を周波数混合器11E-3によって周波数混合し、光周波数変調信号光と局部発振光の光周波数のゆらぎを相殺する。図13に示す実施形態によれば、パイロット信号

を用いることによるゆらぎ成分の除去効果と、図8に示した実施形態と同様のＡＭ変調成分やＦＭレーザの強度ゆらぎを相殺する効果を合わせて得ることができる。

【００５４】なお、上述した本発明の各実施形態は、上記の形態に限られることなく、例えば、他の実施形態として、図9に示すＡＭ／ＦＭコンバータ11Kに換えて、図7に示すＡＭ／ＦＭコンバータ11Dの光電変換器112−3の出力にさらに図11〜13に示すようなバンドパスフィルタ11E−1及び11E−2と周波数混合器11E−3を追加する構成を用いること等が可能である。

【００５５】次に、図15(a)及び図15(b)を参照して、本発明による光信号伝送装置の他の実施形態を説明する。図15(a)に示す光信号伝送装置102は、ＳＬＴ1Jの前段に設けられているプリディストーション回路6と、ＳＬＴ1Jと、光伝送路2と、減衰器7と、ＯＮＵ3Jと、テレビ受像機4から構成されている。ＳＬＴ1Jは、ＡＭ／ＦＭコンバータ11Jと、ＤＦＢレーザ等の半導体レーザ12と、エルビウムドープファイバ増幅器等の光増幅器13から構成されている。ＯＮＵ3Jは、ＡＰＤ等の光受光素子31と、ＦＭ復調部32Jから構成されている。なお、ＡＭ／ＦＭコンバータ11JやＦＭ復調部32Jは、例えば図1に示すＡＭ／ＦＭコンバータ11、ＦＭ復調部32のように、上述した各図を参照して説明した実施形態と同様に構成されるものである。図15(a)に示す光信号伝送装置102では、プリディストーション回路6において後段の回路で歪み補償したい歪みの量と同量の歪みをあらかじめ逆位相で合成することによって歪みの相殺を行う。プリディストーション回路6は広帯域なＦＭ信号に対して動作するのではなく、ＡＭ映像信号の周波数帯域、例えば、90MHzから280MHzで動作すれば良く、また、ＦＥＴ増幅器などで構成することができる。

【００５６】図15(b)はプリディストーション回路6の一構成例を示すブロック図である。図15(b)に示すプリディストーション回路6は、分岐器61、歪み発生回路62、可変アッテネータ63、可変遅延線64、及び合波器65から構成されている。入力された多チャンネルＡＭ映像信号は、分岐器61で２分岐されて、合波器65の非反転入力と、歪み発生回路62へ入力される。歪み発生回路62は入力信号に対して所定の歪みを与え、さらに可変アッテネータ63と可変遅延線64は信号の強度と位相を調整する。そして、可変遅延線64から出力された信号は、合波器65の反転入力に入力され、分岐器61で分岐されたもう一方の信号と合波される。

【００５７】上述したプリディストーション回路6によって得られる作用は、ＡＭ／ＦＭコンバータ11Jで生じる歪みを補償することである。ただし、プリディストーション回路6が入力信号に与える歪みを変化させることによって、さらにＯＮＵ3JのＦＭ復調部32Jで生じる歪みを含めて補償することもできるし、さらに光ファイバ伝送路2によって生じる歪みまでを含めて補償することも可能である。なお、ＡＭ／ＦＭコンバータ11Jで生じる歪みの要因としては、ＦＭレーザの入力電流対出力光周波数特性の動特性における非線形性が考えられる。また、ＡＭ／ＦＭコンバータ11Jにおいて用いている電気増幅器の群遅延偏差が他の要因として考えられる。一方、ＯＮＵ3J内のＦＭ復調部32Jで生じる歪みとしては、それを構成する電気増幅器の群遅延偏差がひとつの要因であり、さらに、ＦＭ復調部32Jの入力周波数対出力電圧特性の非線形性も他の要因として考えられる。また、光ファイバ伝送路２によって生じる歪みの要因としては、伝送用光ファイバの分散がひとつの要因である。したがって、プリディストーション回路6において入力信号に与える歪みは、これらの要因を計算あるいは実験によってあらかじめ求め、さらに必要に応じて入力信号や温度等の他の要因に応じて適宜変化させて、それを補償するように設定、調節するようにすればよい。

【００５８】なお、本実施形態は、多チャンネルＡＭ映像信号を入力信号として説明したが、周波数分割多重された多チャンネルＱＡＭ映像信号を入力としても同様に説明できる。また、映像信号以外でも、アナログでもディジタルでも広帯域な電気信号を入力として同様に説明できる。

【００５９】なお、図15(a)に示す実施形態では、ＳＬＴ1Jの出力段にエルビウムドープファイバ増幅器13を設けてＤＦＢレーザ12の出力光を増幅してから出力し、減衰器7で減衰させてからＯＮＵ3Jに入力しているが、増幅器や減衰器の配置や個数はこの実施形態の態様に限定される必要はない。また、適宜、省略することが可能である。

【００６０】次に、本発明によるＡＭ／ＦＭコンバータの他の実施形態を、図16(a)及び図16(b)を参照して説明する。図16(a)及び図16(b)は、例えば、図1(b)に示すＡＭ／ＦＭコンバータ11の変形例としてのＡＭ／ＦＭコンバータのブロック図をそれぞれ示している。図16(a)及び図16(b)に示す実施形態は、ＡＦＣ（Auto Frequency Controller：自動周波数制御回路）202によって電気一括ＦＭ信号の光周波数ゆらぎを低減することを特徴としている。光周波数ゆらぎは、ＦＭレーザ111−1の発振光周波数のゆらぎとローカルレーザ112−10の発振光周波数のゆらぎから引き起こされる。ローパスフィルタ201は、ＰＤ204、ＦＭ復調部203及びＡＦＣ202を介して入力されるＦＭ復調信号内の低周波数の光周波数のゆらぎ成分を抽出する。この場合、ＰＤ204の入力光は、空いている（ＰＤ112−3に接続されていない）光分岐器112−2の一出力端から取り出している。ローパスフィルタ201によって抽出したゆらぎ成分に応じて、ＦＭレーザ111−1（図16(a)の場合）もしくはローカルレーザ112−10（図16(b)の場合）の光周波数を負帰還制御する。負帰還制御する方法としては、ＦＭレーザ111−1もしくはローカルレーザ112−10への注入電流を変化させる方法、また

は、その温度を変化させる方法などがある。

【００６１】なお、本実施形態は、多チャンネルＡＭ映像信号を入力信号として説明したが、周波数分割多重された多チャンネルＱＡＭ映像信号を入力としても同様に説明できる。また、映像信号以外でも．アナログでもディジタルでも広帯域な電気信号を入力として同様に説明できる。図16(a)及び図16(b)に示す本実施形態によれば、一括変換したＦＭ信号の光周波数ゆらぎによって発生する雑音を低減することができる。

【００６２】なお、図15(a)及び図15(b)あるいは図16(a)及び図16(b)を参照して説明した各実施形態は、それらの図に示す組み合わせに限定されることなく、例えば、図17、図18、図19及び図20に示すＡＭ／ＦＭコンバータ11L,11M,11N,及び11Oように、図1～図14を参照して説明した光信号伝送装置あるいはＡＭ／ＦＭコンバータと適宜組み合わせることが可能である。なお、図17～図20に示す各構成要素には上述の実施形態で使用したものと同一の符号を付けて説明を省略する。

【００６３】また、このほかにも、図4、図6、図7、及び図8に示すような位相の異なる信号を利用して不要強度成分を除去する構成と、図10～図13に示すようなパイロット信号を用いて周波数ゆらぎを相殺する構成を組み合わせること、そして、それらにさらに図15(a)及び図15(b)に示すプリディストーション回路によって歪みを低減する構成を組み合わせることが可能である。また、図4、図6、図7、及び図8に示すような位相の異なる信号を利用して不要強度成分を除去する構成と、図15(a)及び図15(b)に示すプリディストーション回路によって歪みを低減する構成を組み合わせること、そして、それらにさらに図16(a)及び図16(b)に示すＡＦＣによって光周波数ゆらぎを低減する構成を組み合わせることが可能である。

【００６４】

【発明の効果】以上説明したように、この発明によれば、周波数帯域を従来に比べ広帯域化でき、雑音の少ない高品質な信号伝送を可能とする変調方式変換回路及びそれを用いた光信号伝送装置を得ることができる。

【００６５】さらに詳しくは、請求項１～３に記載の発明によれば、電気信号を入力し、光周波数変調した信号光を出力する光周波数変調手段と、信号光を入力して中間周波数へ周波数変換した変調信号を出力する光ヘテロダイン検波部と、前記光周波数変調手段において発生する、光周波数変調手段が発生する信号におけるＡＭ成分を除去する不要強度成分除去手段とを備えるので、光周波数変調信号光に混在するＡＭ成分を除去でき、また、ＦＭ変調成分のスペクトルを中間周波数を中心として対称形なＦＭ変調波にすることができる。また、光周波数変調信号光、あるいは局部発振光の振幅ゆらぎから生じる強度雑音を除去することができる。また、光周波数変調信号光のゆらぎから生じるＦＭ変調成分の周波数ゆらぎを除去できる。また、本発明による光伝送装置は、多チャンネル映像信号の伝送に用いて特に効果があるが、他の信号の伝送にも利用してよく、歪みや雑音の少ない高品質な信号伝送を可能とすることができる。

【００６６】また、請求項４～６に記載の発明によれば、請求項１～３に記載の発明によって得られるのと同様の効果を得ることができる光信号伝送装置を提供することができる。

【００６７】

【００６８】

【００６９】

【００７０】

【００７１】

【００７２】

【図面の簡単な説明】

【図１】　図1(a)は本発明の一実施形態の光信号伝送装置の全体構成図であり、図1(b)は図1(a)に示すＡＭ／ＦＭコンバータ11の内部構成を示すブロック図であり、図1(c)は図1(a)に示すに示すＯＮＵ3の内部構成を示すブロック図である。

【図２】　図2(a)は図1(b)に示す光ヘテロダイン検波部112の出力として得られる電気一括ＦＭ変調成分のスペクトルの一例を示す図であり、図2(b)は図1(c)に示すＦＭ復調部32によって一括して復調される復調多チャンネルＡＭ映像信号のスペクトルを示す図である。

【図３】　図3(a)及び図3(b)は、それぞれ図1(b)に示す光電変換器112-3へ入力される信号光（ＦＭレーザ光）のパワーP_{FM}と局部発振光（ローカルレーザ光）のパワーP_{LO}との比P_{FM}/P_{LO}と、ＡＭ／ＦＭコンバータ11の出力端子において変調信号をＡＭ映像信号に復調したときのＣＮＲの関係を示す図である。

【図４】　本発明によるＡＭ／ＦＭコンバータの他の実施形態を示すブロック図である。

【図５】　図5(a)及び図5(b)は、図4に示す光電変換器112-3へ入力される信号光（ＦＭレーザ光）のパワーP_{FM}とローカルレーザ光のパワーP_{LO}との比P_{FM}/P_{LO}と、同相合成器11B-4の出力端子において電気一括変換ＦＭ信号を復調したときのＡＭ映像信号の複合２次歪み（ＣＳＯ）及び複合３次歪み（ＣＴＢ）の関係を破線で示す図であり、各図にはあわせて実線で図１(b)に示すＡＭ／ＦＭコンバータ11の特性を示している。

【図６】　本発明によるＡＭ／ＦＭコンバータの他の実施形態を示すブロック図である。

【図７】　本発明によるＡＭ／ＦＭコンバータの他の実施形態を示すブロック図である。

【図８】　本発明によるＡＭ／ＦＭコンバータの他の実施形態を示すブロック図である。

【図９】　本発明の一実施形態の光信号伝送装置の全体構成を示すブロック図である。

【図１０】　図9に示すＡＭ／ＦＭコンバータ11Kの内部

構成を示すブロック図である。

【図１１】　図9に示すＡＭ／ＦＭコンバータ11Kの他の実施形態を示すブロック図である。

【図１２】　図9に示すＡＭ／ＦＭコンバータ11Kの他の実施形態を示すブロック図である。

【図１３】　図9に示すＡＭ／ＦＭコンバータ11Kの他の実施形態を示すブロック図である。

【図１４】　図10～図13に示すＡＭ／ＦＭコンバータの各構成例の各部(A)から(G)におけるスペクトルを示す図である。

【図１５】　図15(a)は、本発明による光信号伝送装置の他の実施形態を示すブロック図、図15(b)は図15(a)に示すプリディストーション回路6の構成例を示すブロック図である。

【図１６】　図16(a)及び図16(b)はそれぞれ図1に示すＡＭ／ＦＭコンバータ11の変形例を示すブロック図である。

【図１７】　本発明による各実施形態の組み合わせ例を示すブロック図である。

【図１８】　本発明による各実施形態の組み合わせ例を示すブロック図である。

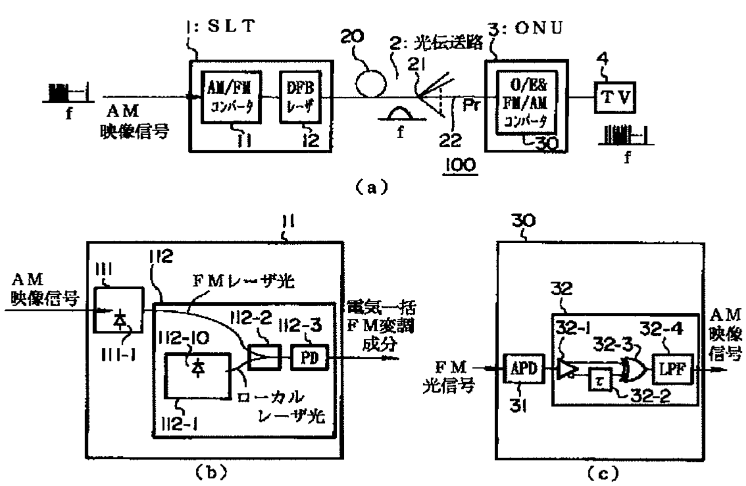
【図１９】　本発明による各実施形態の組み合わせ例を示すブロック図である。

【図２０】　本発明による各実施形態の組み合わせ例を示すブロック図である。

【符号の説明】

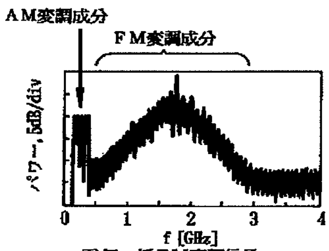
1　ＳＬＴ
2　光伝送路
3　ＯＮＵ
4　ＴＶ受像機
5　合波器
6　プリディストーション回路
11　ＡＭ／ＦＭコンバータ
12　ＤＦＢレーザ
31　ＡＰＤ（光電変換器）
32　ＦＭ復調部
111　光周波数変調部
111−1　ＦＭレーザ
112　光ヘテロダイン検波部
112−1　光周波数局部発振器
112−2　光合波器
112−10　ローカルレーザ
112−3　光電変換器
11B−1　差動分配器
11B−2　振幅調整器
11B−3　遅延時間調整器
11B−4　同相合成器
112C−3　光電変換器（バランスドレシーバ構成）
11C−6　光強度変調器
11C−1　光分岐器
11C−2　ＰＤ
11C−3　振幅調節器
11C−4　遅延時間調整器
11C−5　位相反転器
11E−1, 11E−2　バンドパスフィルタ
11E−3　周波数混合器
201　ローパスフィルタ（ＬＰＦ）
202　ＡＦＣ
203　ＦＭ復調部（周波数復調部）

【図１】



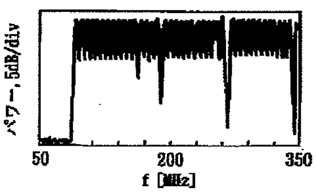
【図２】

（a）



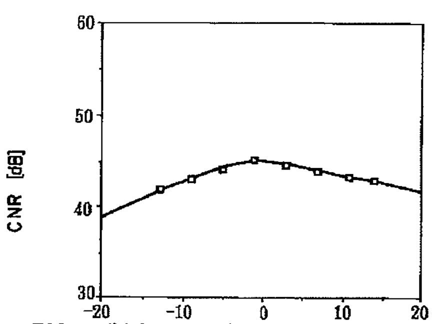
電気一括FM変調信号

（b）

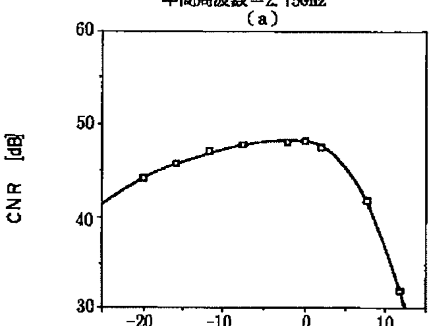


AM映像信号

【図３】

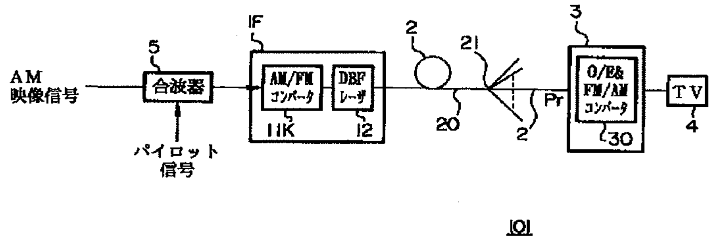


中間周波数＝2.75GHz
（a）

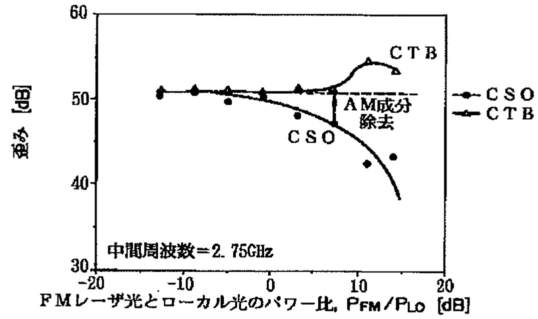


中間周波数＝3.85GHz
（b）

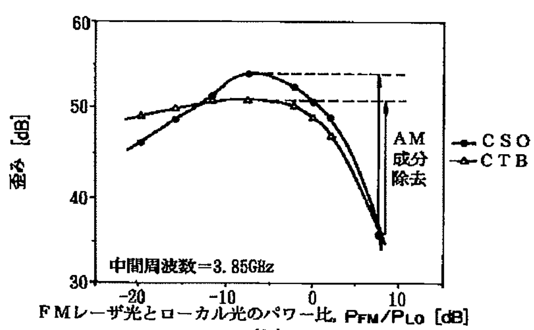
【図９】



【図５】

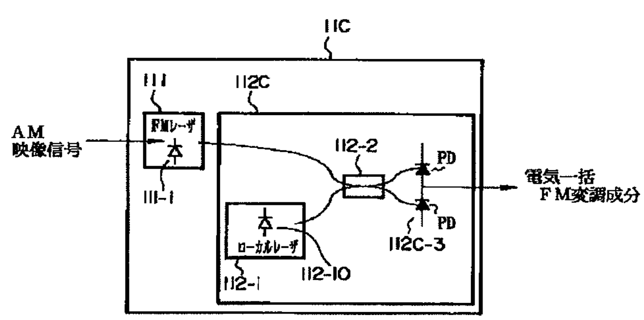


（a）

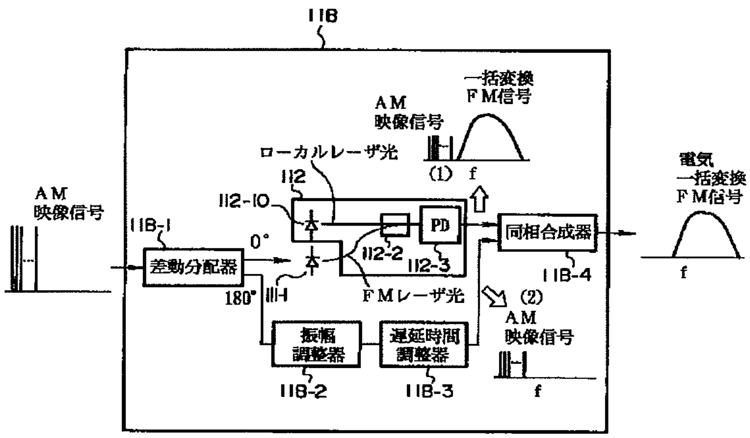


（b）

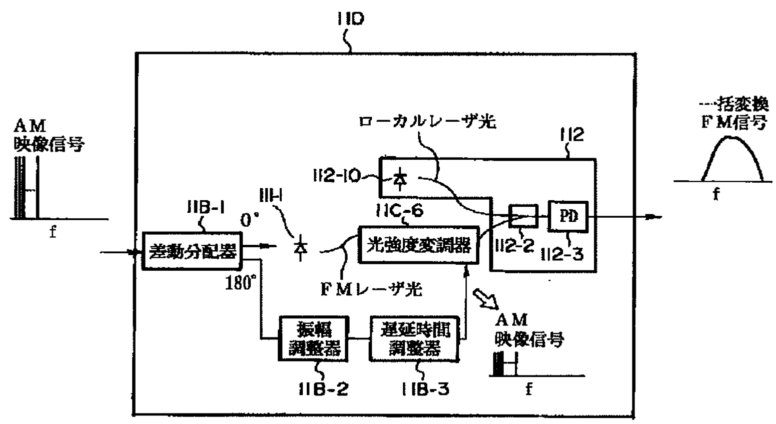
【図６】



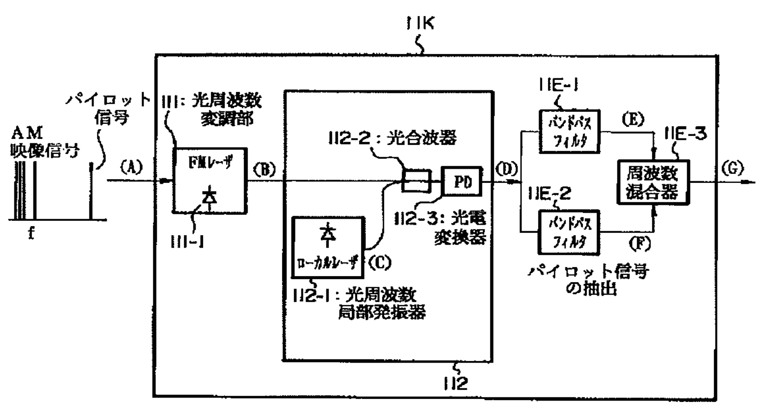
【図４】


11B
AM
映像信号
一括変換
FM信号
ローカルレーザ光
(1) f
112
112-10
11B-1
0°
差動分配器
PD
112-2
112-3
同相合成器
電気
一括変換
FM信号
f
11B-4
180°
111-1
FMレーザ光
(2)
AM
映像信号
振幅
調整器
遅延時間
調整器
11B-2
11B-3
f

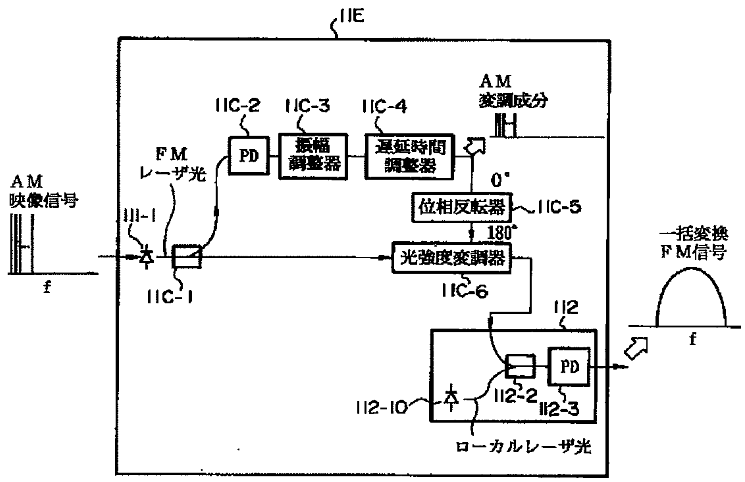
【図７】


11D
AM
映像信号
f
ローカルレーザ光
112
一括変換
FM信号
f
112-10
111-1
11B-1
0°
11C-6
差動分配器
光強度変調器
PD
112-2
112-3
180°
FMレーザ光
AM
映像信号
振幅
調整器
遅延時間
調整器
11B-2
11B-3
f

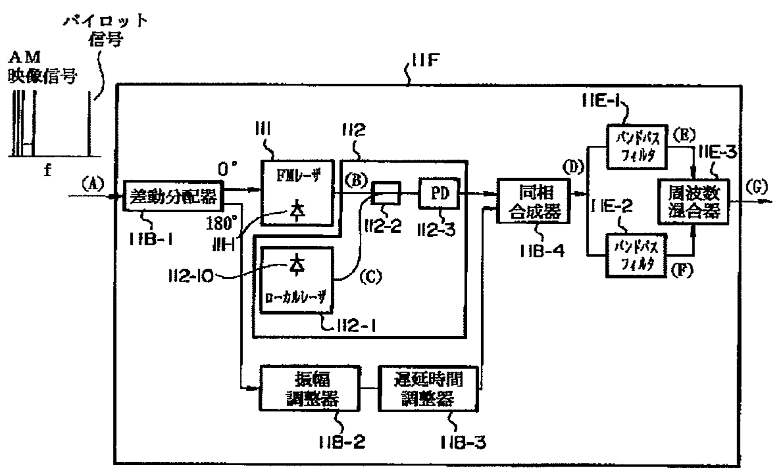
【図１０】


11K
パイロット
信号
111：光周波数
変調部
AM
映像信号
(A)
FMレーザ
(B)
111-1
112-2：光合波器
PD
(D)
112-3：光電
変換器
ローカルレーザ
(C)
112-1：光周波数
局部発振器
112
11E-1
バンドパス
フィルタ
(E)
11E-3
周波数
混合器
(G)
11E-2
バンドパス
フィルタ
(F)
パイロット信号
の抽出
f

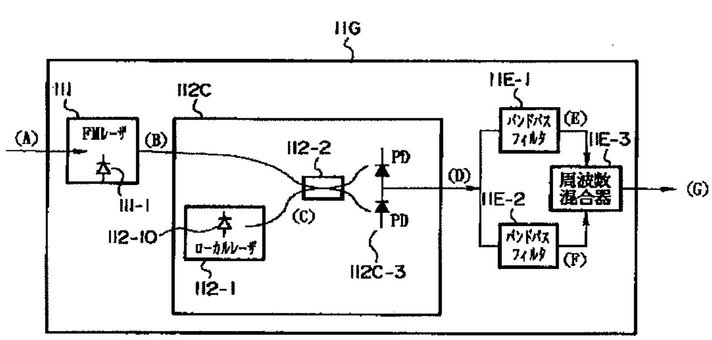
【図８】


11E
AM
変調成分
11C-2
11C-3
11C-4
PD
振幅
調整器
遅延時間
調整器
0°
FM
レーザ光
AM
映像信号
位相反転器
11C-5
111-1
180°
一括変換
FM信号
光強度変調器
f
11C-1
11C-6
112
f
PD
112-10
112-2
112-3
ローカルレーザ光

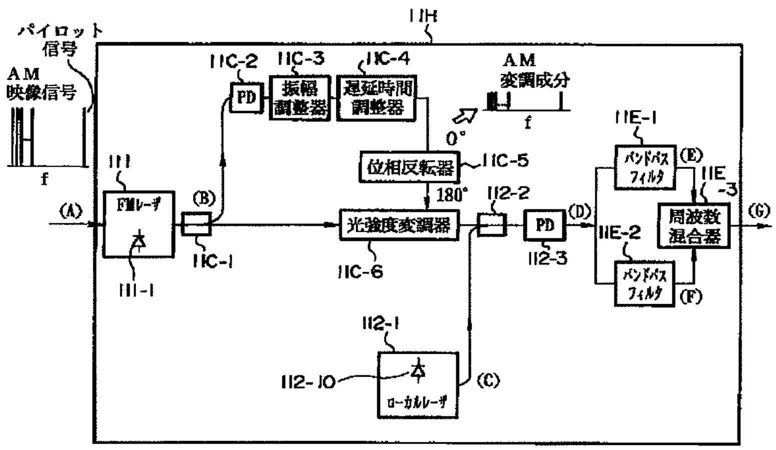
【図１１】


パイロット
信号
AM
映像信号
11F
11E-1
バンドパス
フィルタ
(E)
11E-3
111
112
f
0°
(D)
FMレーザ
(B)
PD
同相
合成器
周波数
混合器
(G)
(A)
差動分配器
180°
11E-2
11B-1
112-2
112-3
11B-4
バンドパス
フィルタ
(F)
112-10
(C)
ローカルレーザ
112-1
振幅
調整器
遅延時間
調整器
11B-2
11B-3

【図１２】

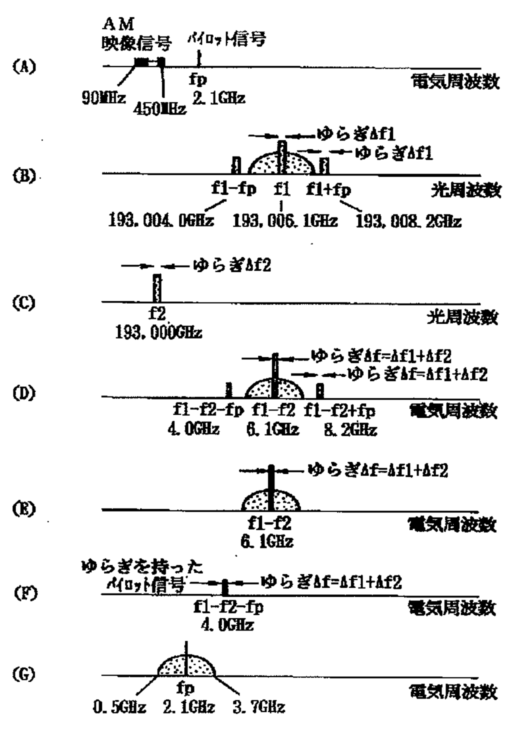

11G
111
112C
11E-1
バンドパス
フィルタ
(E)
(A)
FMレーザ
(B)
112-2
PD
11E-3
(D)
周波数
混合器
(G)
111-1
11E-2
112-10
(C)
PD
ローカルレーザ
バンドパス
フィルタ
(F)
112C-3
112-1

【図１３】



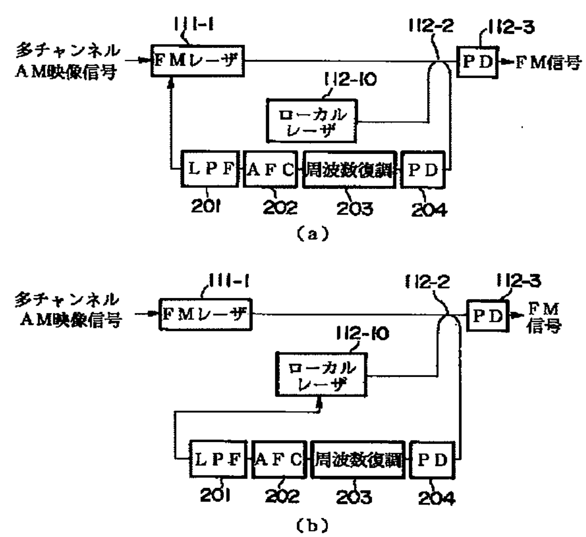
パイロット信号
AM映像信号
f
11H
11C-2
PD
11C-3
振幅調整器
11C-4
遅延時間調整器
AM変調成分
f
0°
111
FMレーザ
111-1
(A)
(B)
11C-1
位相反転器
11C-5
180°
光強度変調器
11C-6
112-2
PD
112-3
(D)
11E-1
バンドパスフィルタ
(E)
11E-3
周波数混合器
(G)
11E-2
バンドパスフィルタ
(F)
112-1
112-10
ローカルレーザ
(C)

【図１４】



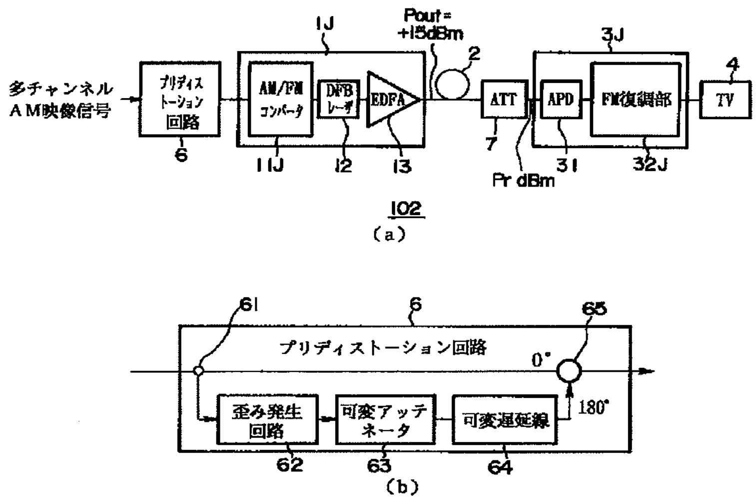
(A)
AM映像信号
パイロット信号
90MHz
450MHz
fp
2.1GHz
電気周波数
(B)
ゆらぎΔf1
ゆらぎΔf1
f1−fp f1 f1+fp
193.004.0GHz 193.006.1GHz 193.008.2GHz
光周波数
(C)
ゆらぎΔf2
f2
193.000GHz
光周波数
(D)
ゆらぎΔf=Δf1+Δf2
ゆらぎΔf=Δf1+Δf2
f1−f2−fp f1−f2 f1−f2+fp
4.0GHz 6.1GHz 8.2GHz
電気周波数
(E)
ゆらぎΔf=Δf1+Δf2
f1−f2
6.1GHz
電気周波数
(F)
ゆらぎを持ったパイロット信号
ゆらぎΔf=Δf1+Δf2
f1−f2−fp
4.0GHz
電気周波数
(G)
fp
0.5GHz 2.1GHz 3.7GHz
電気周波数

【図１６】

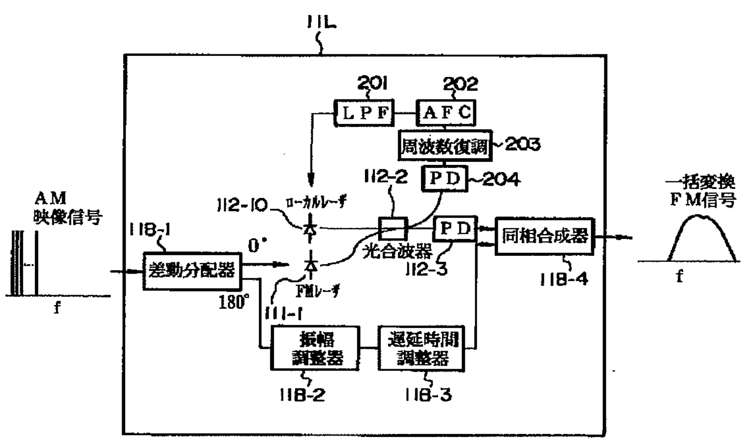


111-1
多チャンネルAM映像信号
FMレーザ
112-2
112-3
PD
FM信号
112-10
ローカルレーザ
LPF
AFC
周波数復調
PD
201
202
203
204
(a)
111-1
多チャンネルAM映像信号
FMレーザ
112-2
112-3
PD
FM信号
112-10
ローカルレーザ
LPF
AFC
周波数復調
PD
201
202
203
204
(b)

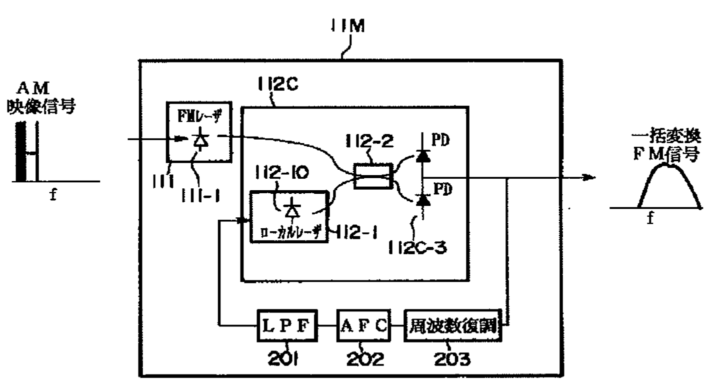
【図１５】


多チャンネル
ＡＭ映像信号
プリディス
トーション
回路
6
1J
AM/FM
コンバータ
DFB
レーザ
EDFA
11J
12
13
Pout=
+15dBm
2
ATT
7
Pr dBm
3J
APD
FM復調部
31
32J
4
TV
102
(a)
61
6
65
プリディストーション回路
0°
180°
歪み発生
回路
可変アッテ
ネータ
可変遅延線
62
63
64
(b)

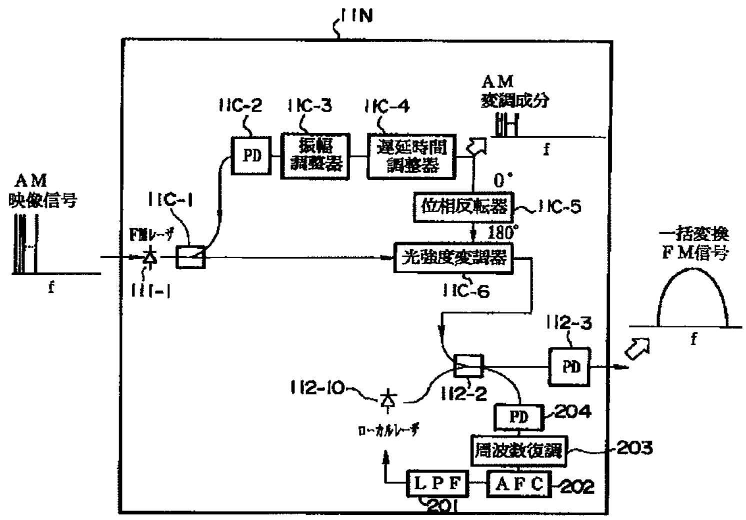
【図１７】


11L
201
202
LPF
AFC
周波数復調
~203
112-2
PD
~204
AM
映像信号
f
112-10
ローカルレーザ
118-1
0°
差動分配器
180°
光合波器
112-3
PD
同相合成器
118-4
FMレーザ
111-1
振幅
調整器
遅延時間
調整器
118-2
118-3
一括変換
FM信号
f

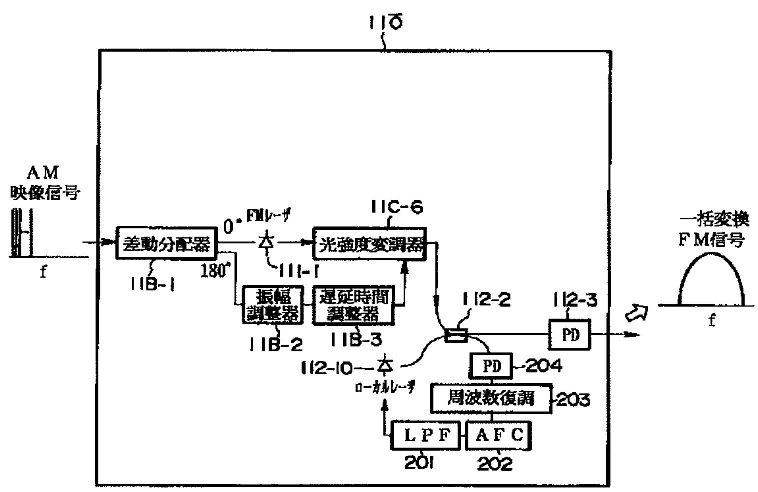
【図１８】


11M
AM
映像信号
f
112C
FMレーザ
111
111-1
112-2
PD
PD
112-10
ローカルレーザ
112-1
112C-3
一括変換
FM信号
f
LPF
AFC
周波数復調
201
202
203

【図１９】



【図２０】



フロントページの続き

(51)Int.Cl.⁷	識別記号	ＦＩ
Ｈ０４Ｂ　10/18		
Ｈ０４Ｎ　7/22		

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(58)調査した分野(Int.Cl.^{7}，ＤＢ名)
H04B　10/00
H04N　7/00
ＩＮＳＰＥＣ（ＤＩＡＬＯＧ）
ＪＩＣＳＴファイル（ＪＯＩＳ）